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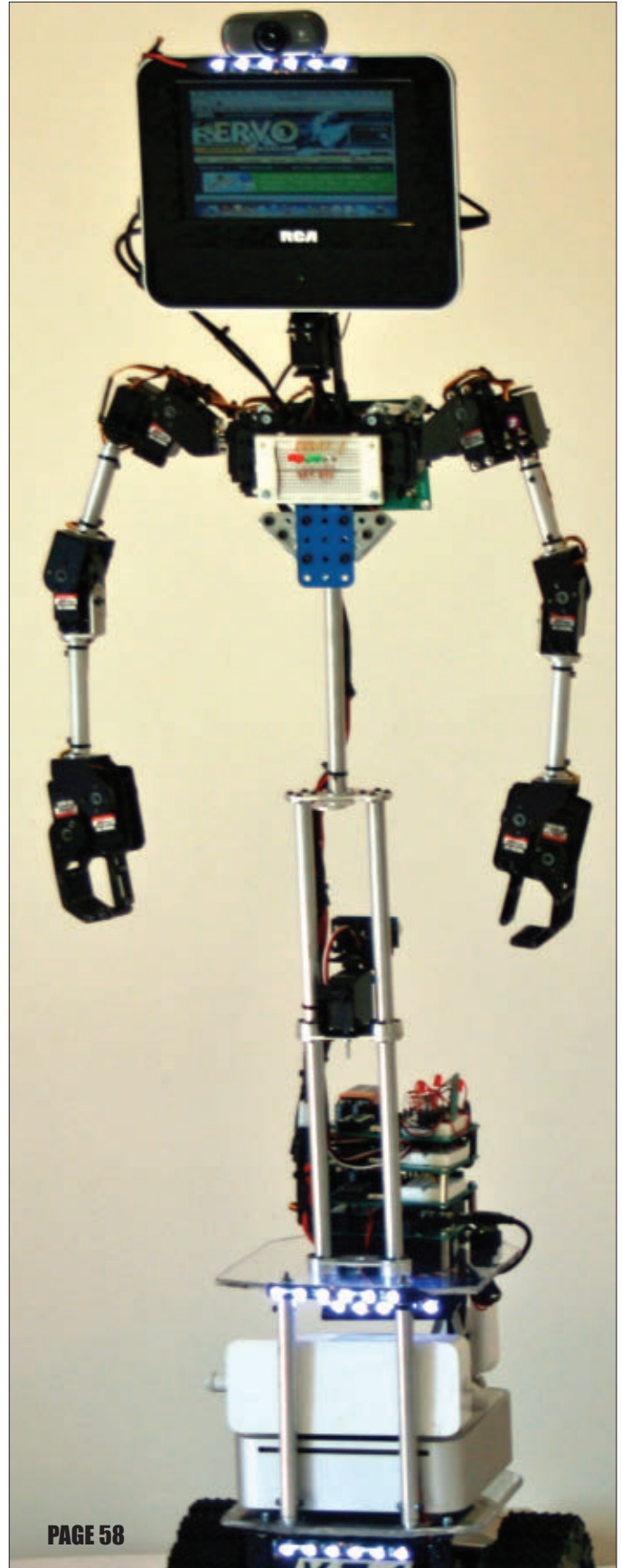
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Mind / Iron

by Bryan Bergeron, Editor



Mobile Platforms

An advantage of using an off-the-shelf robotics platform is that you can focus on the navigation, vision, or other higher level challenges. However, when your robot can't move in an environment, all the AI in the world isn't going to help. This was highlighted recently by the accident at the Fukushima nuclear power station in Japan. An underwater robot was used to explore the damage inside the spent fuel pool. Similarly, a robot was used to measure the radiation levels within the facility. Paradoxically, with all of the 'advanced' robotics development in Japan, the robot used to explore the facility was a US made iRobot PackBot. The floor was reportedly too cluttered for a Japanese robot to operate.

My take-away lesson from this accident is that for real world robots, you can't assume a level, smooth, or carpeted working surface. For example, I've been experimenting with the Freescale walker robot lately. The walker platform is great for enabling me to work on the electronics, sensors, and the like, but mobility is virtually nill unless the robot is on a smooth desktop. Even a few grains of rice on the desktop can render the walking platform useless.

Have you tried your robot outside? I don't mean on your smooth driveway, but on an unpaved road or even a dry ditch. Chances are, you'll need to reconfigure the platform to work within the environment. Even if your robot is based on a four wheel drive R/C truck, you may have to change tire tread to suit the environment.

My experience with underwater robots is limited, but I have tried my hand at a few terrestrial platform designs.

For example, I worked with aluminum crawlers (www.crustcrawler.com) for a while. Unlike many wheeled platforms, it could overcome modest obstacles, albeit rather slowly. Unfortunately, battery life and payload capacity were limited. It was good for about 100 feet on carpet before requiring a recharge.

The US Army hasn't given up on multi-legged robot platforms. You've probably heard of DARPA's MULE — a four legged robot that runs on gasoline. It's not clear when this robot will be ready for active duty. My only experience with a tractor-tread robot is with an upgraded Parallax BoeBot. Like the iRobot PackBot, it is capable of climbing over modest rubble and isn't phased by small pebbles or uneven surfaces. I've even used the tractor-tread BoeBot outside with reasonable success.

My best outdoor, all-terrain robot is based on a Traxxas E-Maxx platform. It has lots of power, lots of speed, and great range. The plastic body pops off, leaving plenty of room to mount an aluminum or plastic plate with sensors. Most experimenters that use this platform change the gearing in the transmission to provide a more gentle start and stop, with more control for steering. The \$400 E-Maxx is a significant investment, but you'd be hard pressed to come up with such a versatile, waterproof platform from scratch.

Of the commercial, all-terrain, outdoor robot platforms, there's the Parallax gasoline powered QuadRover. The 89 pound, four-wheeled robot has a 2.5 HP engine. At \$1,500, it isn't cheap, but if you need a real outdoor robot that can carry a significant payload, the QuadRover looks promising. Have an idea for a new or improved platform? If so, let me hear about it. **SV**

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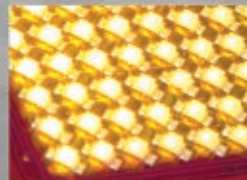
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Robytes

by Jeff and Jenn Eckert

Mechanical Frog Legs Demonstrated

A fairly ingenious device — said to be inspired by a frog — has been demonstrated by Jianguo Zhao and his team, at Michigan State University (www.msu.edu). As you might imagine, building a device that's capable of hopping is not all that difficult, but the problem is getting it to land upright or at least right itself after landing. Here we have a mechanism described as a "controllable and continuous jumping robot" that does the latter, and yet it is driven by only one motor and weighs only 20 g — including the battery.

To power a jump, the motor pulls the little bot's body downward, compressing four springs. Then, the drive gear engages a lever that releases the legs, and up it goes. It invariably lands on its side, but as the motor again pulls its body down to its legs, it also deploys little arms that push it back to a standing position before it hops again. The 8 cm device is capable of jumping about 50 cm skyward, and it can do it 285 times on a single 50 mAh battery. It's not clear that it has any practical use, but it's fun to watch. You can take a look at www.youtube.com/watch?v=XxHRqZQM38.



The frog-inspired jumperbot developed at Michigan State University.

Where are the Books?

No, this isn't Ten Forward on the Enterprise or the snack bar at the Buckminster Fuller Institute. It's the new Joe and Rika Mansueto Library at the University of Chicago (mansueto.lib.uchicago.edu). If it's true that traditional books are a dying species, this \$81 million edifice is all the more appropriate, as all of its books are buried underneath the reading room inside 24,000 metal bins.

If you enjoy meandering down rows of bookshelves and allowing unfamiliar titles to grab your attention, you're out of luck here. In this place, books are fetched by five robotic cranes. You request a particular book from an online catalog and, about five minutes later, it arrives for pickup.

The library has been celebrated as an "automated"



Reading room at the University of Chicago's Mansueto Library.

facility but, in fact, it appears to involve about as much human labor as a standard configuration. Because the storage and retrieval system handles only bins (not individual books), library staff must manually open and close the bins, scan the item's barcodes, and deliver the selected publications to and from the front desk. On the positive side, the

tomes are stored under optimal environmental conditions, so they should still be in nice shape long after e-books have made them obsolete. Plus, visitors get a nice view of the world outside. That has to be worth \$81 million.

In case you are wondering, namesake Joe Mansueto is the billionaire CEO of Morningstar, Inc., and he and his wife kicked in \$25 million of the cost.

Shiver Me Timbers!

ReconRobotics (www.reconrobotics.com) is a provider of tactical micro-robotic systems used by the US military, international friendly forces, and various law enforcement agencies, bomb squads, and fire and rescue teams. One of its products is the Scout Throwbot which — as you might gather from the name — is designed to be thrown through windows, over walls, down stairs, or even dropped from a UAV. The latest news from the company is that it has joined with Space and Naval Warfare Systems Center Pacific (www.public.navy.mil/spawar/pacific) to develop a version with magnetized wheels that "will, among other things, enable the robot to climb up and over the hull of a ship. ReconRobotics believes that this concept could evolve into a new micro-robot platform that would have immediate applications in maritime piracy interdiction and in protecting the lives of shipboard military personnel."

The 1.2 lb unit is even fitted with an infrared optical system for operation in complete darkness. The units will be delivered by an unspecified "marsupial robot deployment system" which is basically a bigger robot carrying the Scout. Given that Somali pirates typically ride around in fiberglass and inflatable boats, the device will unlikely be particularly effective in preventing hijackings. But, at least we may be able to see what they're up to after the fact.

ReconRobotics' Scout Throwbot, being reconfigured to fight piracy.





Francis
the
Talking
Mule,
1950.

A Little Overkill, Maybe

It appears that technology got a little out of hand a few weeks ago when a police robot firing high-tech triple-warhead grenades destroyed a mobile home. Reportedly, police officers used "satellite and heat sensor" technology to track fugitive Junior Kemper Spradlin to a trailer in Blountville, TN, after a high speed pursuit. Spradlin, wanted for second-degree murder, was believed to be hoarding a cache of multiple rifles and pistols, so Blountville's answer to Barney Fife decided to send in a robotic SWAT trooper to take charge. The bot set off some sort of a pyrotechnic grenade, reported by the local newspaper to resemble the Triple Chaser® sold by Defense Technology (www.defense-technology.com) which is designed for outdoor crowd management.

When deployed, three canisters separate and land about 20 feet apart, spewing out a continuous discharge of CN, CS, and Saf-Smoke® gases. In the device's spec sheet, the company warns, "It should not be deployed onto rooftops, in crawl spaces, or indoors due to its fire-producing capability." As a result, the home was turned into an inferno and destroyed.

Oh, I almost forgot. In all of the smoke and confusion, the suspect escaped. **SV**



Mobile home in Blountville, TN,
destroyed by a SWAT bot.

Robots Out, Mules In?

At a recent robotics conference, Jim Overholt — senior research scientist at the Army Tank Automotive Research, Development, and Engineering Center (armytechnology.armylive.dodlive.mil) — revealed that systems such as the BigDog pack robot have achieved less than stellar performance in Afghanistan, leaving soldiers severely burdened with heavy loads in difficult terrain. As a result, officials "at the highest level of the US Army and Department of Defense" are contemplating a solution that dates back to the 1800s: mules.

Apparently the beasts are tough enough to deal with high altitudes and steep mountain slopes, so serious consideration is being given to reviving the Army Animal Corps. There are some obvious drawbacks, however, including the fact that "when a mule gets shot, you don't get to fix the mule." There would also be the requirement of lugging water along for them to drink, and dealing with the famously stubborn animals halfway up a rugged mountainside would be no picnic. But sometimes flesh and blood is still the only means to get the job done.

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GEER HEAD

by David Geer

Contact the author at geercom@windstream.net

Covert Robots

A covert robot seeks to spy without being spotted, see without being seen, hear without being heard, and steal away undetected with its surreptitiously siphoned data. This presents a catch-22 challenge of sorts. How can a robot be equipped to track and capture sights and sounds yet be inconspicuous, even stealthy enough to hide silently nearby?



Covert robot with four Crown GLM-100 microphones, a Hokuyo scanning laser range finder, and electronics visible.

Roboticians began with a Pioneer 3-AT robot as a base, adapting it to nighttime surveillance and installing a set of four microphones. The robot was programmed to select targets to spy on by weighing the value of the target against the likelihood the robot will have a viable escape

route if the enemy should discover it. The engineers also finished the robot with non-reflective paint.

The resultant calculations enable the robot to be out of sight of a guard or sentry an additional 25 percent of the time, according to a Lockheed Martin Advanced Technology

Laboratories paper by Tom Moore, et. al.

Hardware Configuration, Environmental Mapping

The Lockheed Martin engineers added a motherboard with a 2.4 GHz dual core chip, a power supply, and a hard drive to the Pioneer robot. Using an audio capture card, the robot can detect and process sounds which point to the position and approach of any sentries at the target location. The microphones are mounted at the highest possible location within the robot's dimensions. The engineers used a mic preamp to boost signals to the sound card.

A long range LIDAR is mounted even higher up on the robot, while a short range LIDAR was mounted under the robot. These detect distant obstacles and immediate obstacles, respectively. A 6-DOF, gyro stabilized GPS/IMU unit mounted atop the robot provides the course setting, attitude, and vehicle speed data.

The robot uses "cost maps" on a 2D grid that hold the locations of obstacles. The low obstacles are identified as places the robot could not hide, while the high obstacles are noted as places the robot could hide from a sentry. There are different types of cost maps too, including individual intervisibility, generalized intervisibility, light levels, desirability, and one that shows how easy it would be for the robot to run away if a sentry was nearing it (escapability).

The desirability map demonstrates the degree to which the target location to be viewed is visible from a given cell. Before any mission, the operator draws a circle around the target area that the robot should get a good view of. The cells that are part of the target area are initially considered to be desirable.

While the desirability map helps the robot to choose goals that are hidden yet allow line-of-sight with the target location, it does not consider locations that enable the robot to easily escape. It does not identify, for example, a dead end in an alley as inescapable. The escapability map shows how easily the robot could escape from any given cell. Using both maps, the robot selects goals or cells that are both desirable and escapable, narrowing its options to the best overall. Preferably, the robot will have several directions by which it can escape a guard.

Escapability is determined by cells where opposing and



orthogonal rays of substantial length pass through. Escapability calculations and generalized intervisibility calculations (discussed later) have an inverse relationship. While the cell or area that is most escapable has rays of infinite length in all directions (not stopped by obstacles), these areas or cells would be the worst for intervisibility.

Combining Map Data To Achieve A Target Goal

Based on the cost maps, the robot determines the overall stealth cost, escapability, and desirability of each cell, and calculates its goals accordingly. Obviously, the robot selects the cells with the least stealth cost and the greatest desirability and escapability over other cells when planning its goals and course of movement.

Since the robot is designed to take advantage of low light/no light in nighttime operations, it considers light sources when navigating and avoids them as much as possible, as well. The robot seeks out the cover of shadows and avoids light sources while maintaining considerations for the various maps.

The robot uses a map of existing light sources in a region rather than detecting light sources in real time. This makes flashlights, headlights, and other unpredictable movable light sources a challenge. Light sources are assigned costs based on the cell through which the light passes. Each additional light source per cell adds to the cost of a cell with only one light source.

Sentries are an interesting variable in this mix of maps. If the robot knows the location of a sentry, it can determine what is or is not visible to the sentry and avoid areas where it would become visible. Because people can turn around and view in all directions, the robot assumes the sentry has omni-directional vision, or that it can see in all directions at once.

Each cell with a ray passing through it is assumed to be visible by the sentry if it is within 50 m of the sentry (the distance limitation of human sight at night). Because rays can diverge and shine light in a cell where no cost is assigned (assuming one ray alone could not light the cell), the robot calculates cells where two rays diverge by a distance of at least the diagonal width of a cell and assigns a cost there. Objects that block rays throw a monkey wrench into these types of calculations as some rays will not persist to a distance to create the divergence.

If Sensors Fail

If the robot's sensors fail and it cannot locate the sentries, the robot will remain as covert (hidden) as possible. The robot accomplishes this using a generalized intervisibility map. This map rates the coactiveness of an area or cell based on its visibility from any other area or cell.

The robot's objective is to view a target location such as a building. The robot wants to see the location without being seen. Therefore, the robot should not get any closer to the location than necessary to view it appropriately. To do this, the robot considers buildings as dangerous objects with a much higher generalized visibility cost so that it will automatically avoid getting too close to them.

The cost maps are calculated in the following order: The stealth map is calculated first, then the individual intervisibility cost map is next, followed by the generalized intervisibility cost; then the cost from light sources. The robot then chooses a course based on the cells that have desirability cost. The robot generates a path it will take and is capable of changing its path dynamically as the environment changes with objects and/or sentries appearing or changing their locations.

The robot uses a "finite state machine" to switch tasks/behaviors from goal seeking to observing to hiding to waiting. Each task or behavior determines the robot's actions based on its current circumstances, i.e., location and environmental information. The goal-seeking behavior determines the robot's actions while in motion. The observing behavior takes charge when a goal is reached so the robot can watch the location. The robot hides when it detects threats such as sentries. It waits when it sees that

all potential paths to the goal are beyond the detection thresholds.

Figures derived from actual trials demonstrated that the robot should weigh its calculations with 80 percent for stealthiness and 10 percent for both desirability and escapability of goals or cells.

Conclusion

Future work should enable the robot to automatically weigh stealthiness, desirability, and escapability against each other based on sensor configuration, environment, and robot state. **SV**

Resources

Lockheed Martin
www.lockheedmartin.com

The Pioneer 3-AT
www.mobilerobots.com

Hokuyo scanning
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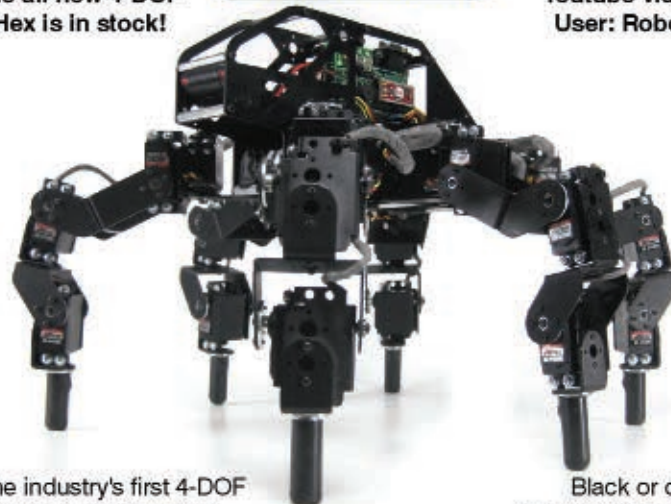


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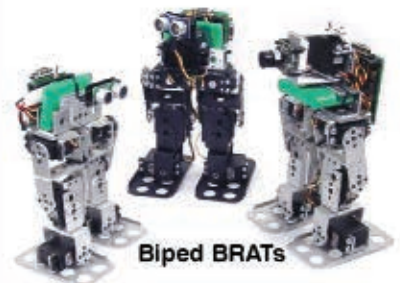


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ASK MR. ROBOTO

by
Dennis Clark

I didn't have a lot of questions this month, but what I did get sure caused a bunch of research. I wish that I had time to program up some examples, because they would be very cool. So much to do, so little time! I hope that everyone is busy building and programming bots and that is why it has been so quiet.

Robotics is composed of so many areas of expertise, mechanical, electronic/electrical, and programming that it can be a formidable hurdle to just get started. But oh, the satisfaction when you succeed!

My first question involves one of the highest hurdles to get over.

Q . I am sure you have heard this a million times before. I'm new to robotics and I don't know how to attach wheels to my motors. Can you help me?
 — **Clueless Mover**



Figure 1. DIY efforts. The one on the far right adapts a shaft to LEGO wheels.

A . Yes, I have heard this one before. I have solved this problem in a number of ways over the years, starting with DIY methods that sometimes even worked. My DIY efforts got more sophisticated when I gained access to folks with lathes and mills. My first efforts were matching motors that I found or got from surplus vendors to wheels that I had from RC car racing or — my favorite — LEGO Technic kits. **Figure 1** shows my DIY efforts. Sometimes you can just "fake it".

Figure 2 shows me using a REALLY big servo disk. It worked, and if I found some small rubber bands would even get traction! The robotics hobby industry has gotten into the act and creates kits and motor sets now that work for basic needs. **Figure 3** shows a hub set from Jameco (www.jameco.com) that matched some of my commonly found surplus motors. I just had to carefully drill out wheels to use the bolt patterns. The Mark III kit (www.junun.org/MarkIII/Store.jsp) created specially molded wheels to match hobby servo shafts for their robot kit (**Figure 4**). I really like this chassis. It is simple and very usable in lots of robot tasks, including its original purpose — robot mini Sumo.

Other companies also made custom wheels that used servo hubs attached to them; the one I show in **Figure 4** came from Budget Robotics (www.budgetrobotics.com). Solarbotics (www.solarbotics.com) has DC gear motor sets that they matched their own molded wheels to (**Figure 5**). These motors did not mount easily to established bases, but by using double-sided sticky tape (also called servo tape in the RC hobby), they attach well just about anywhere.

You can get pretty creative with the solutions that I've mentioned so far, but nothing beats a motor/hub/wheel combination that is meant to go together.

There are now robot hobbyist companies that do supply just that. Some of the ones that I know of are:

www.solarbotics.com
www.pololu.com
www.lynxmotion.com

Figure 6 shows my latest mini Sumo that is using a set of Solarbotics wheels/hubs mated with Pololu micro-metal gear motors. This setup rocks because I didn't have to find a machinist or hack something together! However, these are for small robots. If you need to put wheels on big motors for big robots, you'll need to go down another path. A great source of motors and wheel/hub combinations is www.banebots.com. These guys work with the RobotWars style of big to really big machines that use electric motors and wheels to drive them.

www.therobotmarketplace.com has large bore hubs and large wheels, however I didn't see any matched sets. You would have to mount the hubs to the wheels yourself which can be a dicey thing to do in your garage without precision tools and know-how.

These are the only companies that I know about. If you know of some that I didn't mention, email me at roboto@servomagazine.com to let me know.

I would be remiss if I didn't mention another source of powerful and ready-made robot wheel/hub/motor combinations: Robotis and RoboBuilder. These two companies make affordable Sumo-One style biped humanoid robot kits. Their motor combinations can be used either servo style where you tell them a position to go to, or motor style where you tell them the speed to run at. Both of these company's servos are daisy-chained, controlled by a serial link bus, and include torque measurement and position encoders. They are best used with smaller (under 10 pound) robots.

Figure 7 shows the Robotis Dynamixel motor/wheel set and **Figure 8** is the RoboBuilder motor/wheel set. In the USA, the Robotis Bioloid kits can be found at www.trossenrobotics.com, www.robotshop.com, and www.roadnarrows.com. The RoboBuilder kits and supplies can also be found at www.roadnarrows.com and kits only can be found at www.robotshop.com.

These last two options are the most expensive of the smaller motor/wheel combinations. However, they are the most sophisticated of the sets that I've mentioned because they are motor, motor driver, motor controller, force feedback, and position encoders all rolled into one package. (Think really strong, hobby servo with feedback).

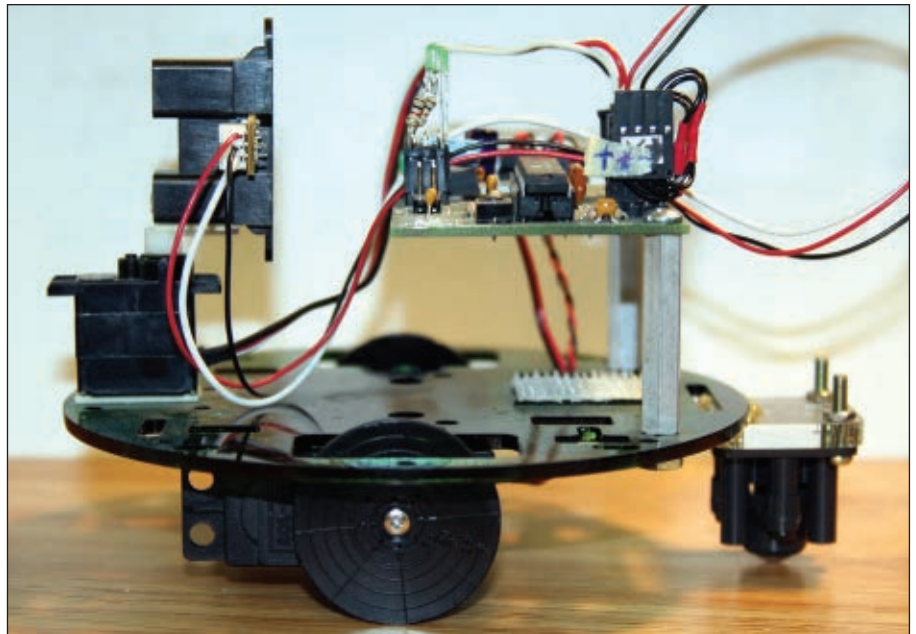


Figure 2. REALLY big servo disk as a wheel.

Q - I want to remotely control robots, RC cars, servos, etc., over the Web. How is this done? Are you familiar with any company that sells the software and hardware that does this? I have come up with very little in my Web searches. Thanks.

— Ed

A - I have not been able to experiment with this much yet. It is on my radar, however, so I do know of some hardware and software programs that handle this task. In my research, I have found that the easiest way to accomplish this goal is to make the robot/device that you want to control be a web server with links to the hardware. In that way, you can use any browser to connect to the robot to send commands and get feedback.

The most expensive, of course, is to just put a computer on your robot, run a server there, and attach (via



Figure 3. Jameco motor hubs.

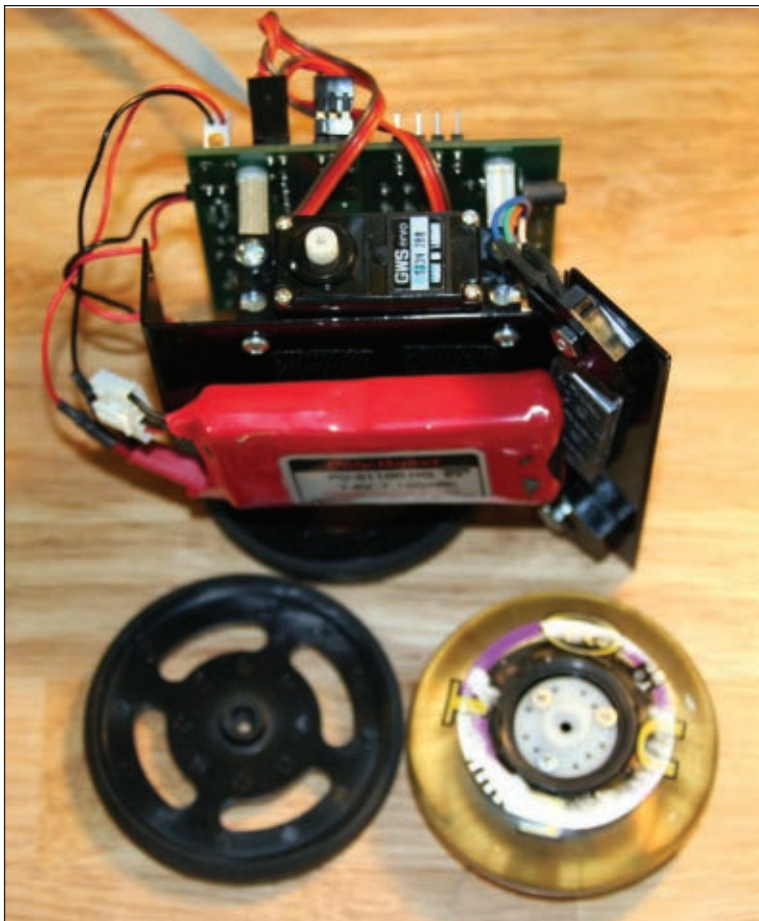


Figure 4. Mark III chassis with servo matching hubs.

USB or serial control) hardware to control the robot. If you want to take this path, you really need to check out RoboRealm since it simplifies the handling of robot vision controls and feedback, as well as connections to low level hardware through scripts that talk to serial or USB devices connected to your computer and the robot. Check out **www.roborealm.com** and see if this is what you are looking for. Heck, check it out anyway. This is cool and inexpensive software.

Putting a computer on your robot might be a challenge if it is a small one. Fortunately, there are ways to put smaller and far less power-hungry microcontroller based Internet boards with servers designed for controlling embedded hardware (like a robot) on your device. I am assuming from your question that you don't want to develop your own Internet server setup from raw components. There are many Ethernet and Wi-Fi enabled devices available that will allow that, but it will be a "heavy lift" to learn them and develop your own platform. With that in mind, the field of suggestions narrows to "out of the box" and fully enabled devices that you can talk to over a simple serial connection.

I'm not surprised that you are having trouble finding what you want. It seems that there are a number of Wi-Fi and wired Ethernet-to-serial modules out there, but with one exception they hide from us. And that exception is ...

The first one that I can think of is the Netburner series of products. These are all full Ethernet enabled servers that connect to your local embedded system or robot through a serial connection of some kind. Netburner is soon to come out with Wi-Fi expansions to their serial-to-Ethernet modules (maybe by the time you read this column). The boards that appear to be what you are looking for will most likely be the SBL2E-100IR and SBL2E-200IR (around US \$30). If you want a board wrapped in a box, the SBL2EX-100IR or SBL2EXA-100IR (around US \$100) might be of interest. These are not Wi-Fi however. They will need the Netburner Wi-Fi adapter which I thought was a little difficult to understand from their site. These modules are available directly from **www.netburner.com**.

Fred Eady describes an iWEM-1001 Wi-Fi module in the June '11 issue of *SERVO Magazine* that you should look into. The iWEM-1001 (1002 with integrated antenna soon) is a complete 802.11 (Wi-Fi) implementation with a standard UART interface that provides the means for server functionality. I found these at **www.lemosint.com** for around US \$40.

The Wiznet WIZ610WI series module is another fully integrated 802.11 Wi-Fi module that gives you a serial-to-Internet connection. Like the iWEM-1000 series, this device has

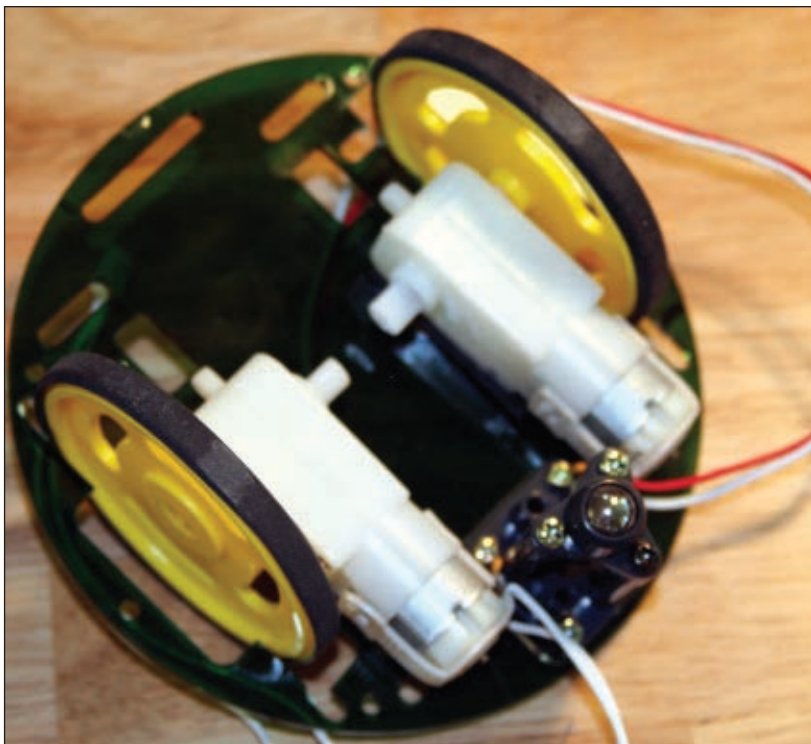


Figure 5. Solarbotics motors with wheels.

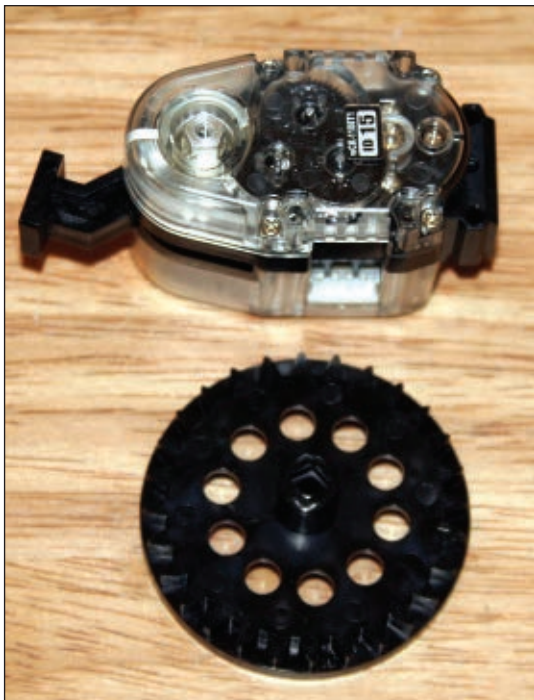


Figure 8. RoboBuilder motor/wheel combination.

several modes including a web server to simplify your interface to the outside world. I found these modules at **www.futureelectronics.com** for around US \$45.

The last Wi-Fi module that I looked at was the WiFly GSX 802.11b/g serial module from Roving Networks (who provide Bluetooth connectivity as well). The WiFly GSX does not have a server mode; it does have FTP and a Thin Client that will allow control in a similar manner to other Wi-Fi embedded solutions. I found these modules at **www.mouser.com** for around US \$40, but they are surface-mount modules only. Over at **www.sparkfun.com**, this module is available mounted on a breakout board for easy hobby use for US \$85.

All of these Wi-Fi modules require that you get an antenna; they don't come with them. However, some will be coming out soon with integrated antennas. Each one of these modules will give you the connectivity you are looking for to put a device or robot on the 'net. You will still need to write some software for your on-board device to talk to the modules over their UART or SPI interfaces, unless you are doing simple sensor reporting projects. (Most of these modules support this on power-up).

These modules are by far the easiest way to put your device on the 'net, but there are things you'll still need to do. The modules simply remove the need for you to create your own network stack.

Another task you will need to accomplish — and this is beyond the scope of this column — is to deal with your router's firewall. If you want your device to be controlled from the outside world, you'll need to configure your

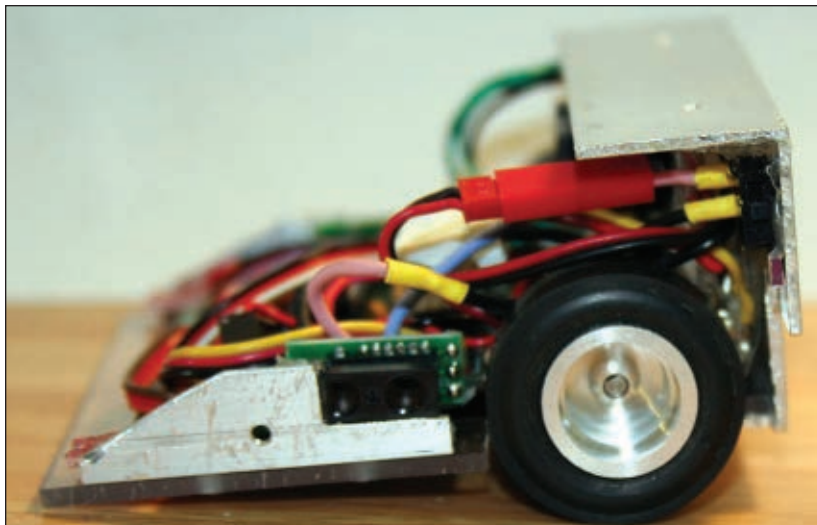


Figure 6. Solarbotics wheels on Pololu gear motor in a mini Sumo robot.

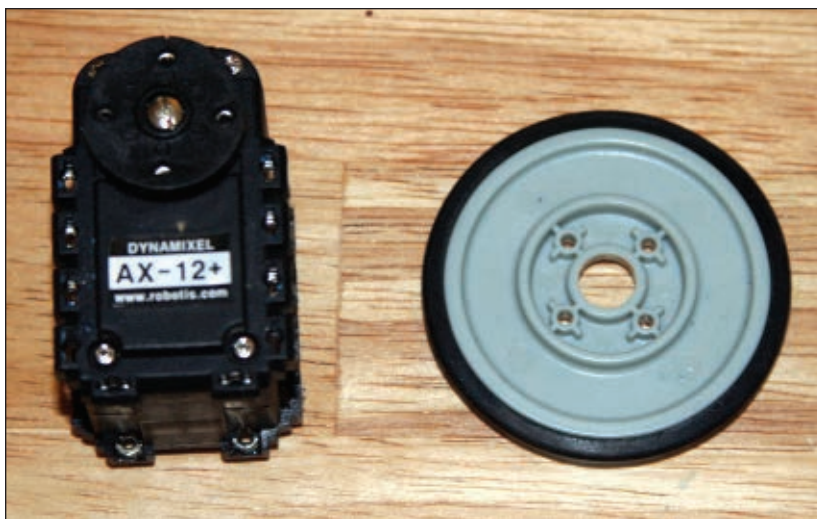


Figure 7. Bioloid Dynamixel motor/wheel combination.

firewall to allow access to your specific port and then create some kind of security to keep the riffraff out. There are plenty of sites on the Web that will tell you how to accomplish this, so don't sweat it.

I have to say, this question has intrigued me. I will need to pick one of these options and do this myself. With the low cost of these Wi-Fi modules and their (typical) range of 330' (100 m), they make a very reasonable alternative to Bluetooth radios and open up the capability for anyone with a Web browser to join in on the fun.

Well, that's it for this month. (Whew!) There may not have been many questions, but they involved some serious sleuthing skills. If you see anything that I may have missed or simply want to comment on it (Thanks Paul Frenger!), please feel free to drop me an email. And, as usual, if you have a question send that to me at roboto@servomagazine.com. I love to hear from you and will do my best to answer your questions. Until then, keep on working on those robots! **SV**

EVENTS

Calendar

ROBOTS.NET

Send updates, new listings, corrections, complaints, and suggestions to: steve@ncc.com or FAX 972-404-0269

Know of any robot competitions I've missed? Is your local school or robot group planning a contest? Send an email to steve@ncc.com and tell me about it. Be sure to include the date and location of your contest. If you have a website with contest info, send along the URL as well, so we can tell everyone else about it.

For last-minute updates and changes, you can always find the most recent version of the Robot Competition FAQ at Robots.net: <http://robots.net/rcfaq.html>
— R. Steven Rainwater

AUGUST

6 **Chibots SRS Robo-Magellan**
Moraine Valley Community College, Palos Hills, IL
A way-finding competition for autonomous robots that requires robots to navigate real world obstacles while locating orange cones.
www.chibots.org

7-11 **AAAI Mobile Robot Competition**
San Francisco, CA
This year's events for autonomous robots include the Learning from Demonstration challenge, the Miniature Humanoid Obstacle Avoidance Challenge, and the Small Scale Manipulation Challenge.
www.aaai.org/Conferences/conferences.php

8-12 **AUVS International Aerial Robotics Competition**
Betty Engelstad Sioux Center, UND Grand Forks, ND
This year's challenge requires advanced autonomous indoor flying. The organizers promise the contest "demands more advanced behaviors than are currently possible in any existing aerial robots."
<http://iarc.angel-strike.com>

15 **Missouri State Fair Robot Expo**
Missouri State Fair, Sedalia, MO
This year's event is called Show-Me Robotics and includes competitions for FIRST Lego League, FIRST Tech Challenge, FIRST Robotics, BEST Robotics, and BOTBALL. In addition, 4-H and local hobby groups will be holding competitions open to all robot builders.
www.mostatefair.com/Special-Events.php

16-20 **World Robotic Sailing Championship**
Lübeck, Germany
Three classes of robot boats will compete: MicroTransat, Sailboat, and Design MicroMagic. This year's challenge is focused on testing control algorithms and boat performance.
www.roboticsailing.org

31 **Homebrew Robotics Club Challenge, TABLEBot Phase II**
Google, 1400 Crittenden Lane Mountain View, CA
HBRC is holding a three-phase TABLEBot challenge in 2011. Phase I was on June 29, Phase II is August 31, and Phase III is October 26. Each phase test is a more complex behavior of table-top autonomous robots.
www.hbrobotics.org

SEPTEMBER

2-5 **DragonCon Robot Battles**
Atlanta, GA
Remoted controlled machines destroy each other as entertainment for science fiction fans and cosplayers.
www.dragoncon.org/

12-15 **International Micro Air Vehicle Competition 't Harde, The Netherlands**
Indoor and outdoor events for tiny flying robots. Also a special contest for Parrot AR Drones which are relatively huge compared to the typical MAV. Parrot is sponsoring this year with free loners of Parrot AR Drones to participating teams. All events are for fully autonomous robots only; no remote control allowed except for tech demonstrations.
<http://www.imav2011.org/>

17 **Robotour**
Vienna, Austria
Autonomous robots must navigate through a public park, carrying a payload that consists of a five liter barrel. All robots receive a map and destination coordinates prior to the race and all bots will start concurrently.
www.robotika.cz/

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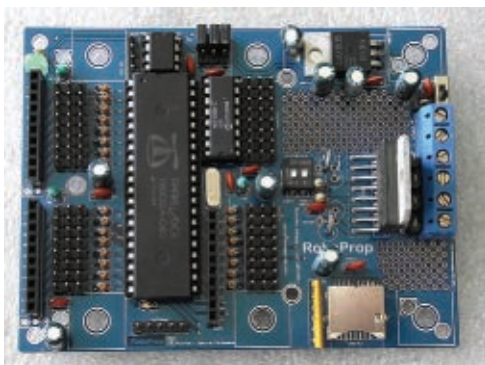


Four unique Arduino proto shields!

TechnologicalArts.com

NEW PRODUCTS

RoboProp Controller Board



Mikronauts RoboProp is an advanced eight core 32-bit RISC robot controller with on-board motor driver, ADC, and up to 32 GB of storage.

RoboProp is the latest in controller boards designed for students and hobbyists. Unlike conventional robot controller boards, RoboProp can be programmed with a native development environment running right on RoboProp with the addition of an inexpensive video output / PS/2 keyboard module and a uSD card pre-loaded with SphinxOS.

RoboProp has eight dedicated 12-bit analog inputs, and 24 I/Os that can be used for servos, digital inputs, encoders, other Mikronauts I/O and prototyping boards, an optional on-board L298 dual motor driver, and the on-board SD card. RoboProp also provides separate I²C and 3.3V serial communications ports and two small prototyping areas.

RoboProp features include:

- * 4.000" x 3.050" standard form factor with standard mounting hole pattern.

- * Designed to fit onto a BOEBOT as an upgrade.

- * Designed to fit Dagu "Mr. Basic" and "Arduino Motor" robot platforms.

- * Parallax Propeller processor with eight 32-bit cores running at 100 MHz.

- * 64KB EEPROM.

- * uSD for data logging and program storage.

- * L298 full H-bridge driver with up to 2.5A drive with a large heatsink per motor (3A peak).

- * Optional current sense resistors.

- * Eight channel/12-bit ADC for three-pin 5V sensors (MCP3208).

- * Up to 24 channels for servos or digital inputs.

- * Mikronauts I²C connector for upcoming Mikronauts I²C modules.

- * HCOMM connector for programming via a Propeller Plug or Mikronauts SerPlug.

- * EXP connectors for breadboards and Mikronauts modules.

- * Can use FlexMem for SRAM/FLASH/FRAM/MRAM memory expansion (uses 6-8 I/O pins).

- * Can add the upcoming MCP3208 module for an additional eight analog input channels (uses four I/O pins).

- * Can stack on other Mikronauts CPU boards and breadboards with stacking headers for EXP1/EXP2.

- * Two small, high density prototype areas.

- * Screw terminals for Vin/GND, MotorA, and MotorB.

- * On-board 5V and 3.3V regulation.

- * RoboPropDiag diagnostic software for testing and exercising.

ADC/SERVO/L298 features included:

- * Uses OBEX objects for PWM, servos, and ADC.

- * FSRW26 modified for RoboProp's uSD settings included.

- * Extra mounting holes for sensors and other platforms.

For more information, please visit:

Mikronauts

Website: <http://mikronauts.com/roboprop/>

Power Gearbox

The new SPG785A-5.0 servo power gearbox from servocity.com is a patented rectangular tube gearbox designed to be extremely versatile.

Trading total rotation for power and precision is what this gearbox is all about.

The power plant of the

gearbox is the ultra-popular

Hitec HS-785HB servo which rotates 3.5 turns right out of the box. The internal potentiometer provides positioning feedback which allows the gearbox to perform accurate and repeatable motions. The user selects a gear ratio that provides the amount of torque and rotation that best suits the application. The lower gear ratios provide more precision and power while the higher ratios offer more speed and rotation. The dual ABEC-5 precision ball bearings and 3/8" stainless steel shaft are able to handle extreme loads from any direction. The stainless steel shaft has a .290" bore to allow wires from cameras, sensors, and other devices to pass through and protect them from being tangled when operating the gearbox. The rigid 6061 T-6 aluminum body offers several mounting options so that the user can mount it in any orientation. Various attachments can easily be coupled to the aluminum hub



by utilizing the 5-40 tapped holes. The SPG785A-5.0 tube gearbox can be purchased in kit form or as a fully assembled unit that is ready for use.

For more information, please visit:

ServoCity

Website: www.servocity.com

Wixel Shield for Arduino



Pololu announces the release of the Wixel shield for Arduino — an easy and affordable way to add wireless functionality to an Arduino or Arduino clone. The Wixel shield offers more than just a general-purpose wireless serial link between an Arduino and a remote computer or embedded system. It can also wirelessly program the Arduino using the standard Arduino computer software and wirelessly debug sketches with the Arduino serial monitor. The Wixel shield seamlessly enables a wireless link to function as the standard Arduino USB connection without interfering with the Arduino's built-in USB interface. The wireless link is maintained by a pair of Pololu Wixel modules: one plugs into a socket on the Wixel shield and the other can be connected directly to a computer via USB (creating a virtual COM port) or to the TTL serial lines of another serial device. This connection has a range of approximately 50 feet under typical indoor conditions. These Wixels can be loaded with an open-source Wixel Shield app to allow wireless Arduino communication and programming, or with custom Wixel apps that augment the Arduino's capabilities with the Wixel's additional processing power, I/O lines, and hardware peripherals.

The shield offers several additional features:

- * Prototyping space for easier/cleaner construction of custom circuits.
- * Shield-accessible Arduino reset button and pin 13 LED.
- * Four general-purpose 2/3 voltage dividers (can be used to safely connect 5V signals to 3.3V inputs).
- * Two general-purpose MOSFETs (can be used as level shifters or high current outputs).
- * Wixel socket allows the Wixel to be removed and used for other applications.

The shield (item #2500) is available for \$12.95, and a

combination deal (item #2501) that includes the shield and a pair of Wixels is available for \$49.95.

For more information, please visit:

Pololu Corporation

Website: www.pololu.com

HS-7235MH and HS-7245MH High Voltage, Coreless, Premium Mini Servos



Hitec announces their high voltage, coreless, premium mini servos: the HS-7235MH and HS-7245MH. The HS-7235MH and HS-7245MH servos deliver exceptional speed and torque in a compact package. Built with an efficient coreless motor optimized for 7.4V operation and heavy-duty metal gear train with dual ball bearings, these high-end mini servos deliver excellent performance. Whether they are used for flying mid-size gas and electric airplanes, 500-550 electric helis, or driving 1/12th scale on-road racers and 1/18th scale rock crawlers, the speed and full-size muscle of these servos offer powerful versatility.

X1 AC Plus Battery Charger

Hitec also announces their new X1 AC Plus battery charger that can go everywhere you go. Capable of

charging all battery types, this charger is an affordable and portable answer to keeping batteries charged and ready for action. The 50-watt X1 AC Plus will charge all batteries at rates from 0.1 to six amps, using either 11-18V DC or 100-240V AC power sources. Designed to charge NiMH, NiCd, LiPo, LiFe, Li-Ion, and lead-based batteries, the X1 AC Plus is a perfect charging solution for RC hobbies. Drivers and pilots alike will appreciate its price and its dependability.

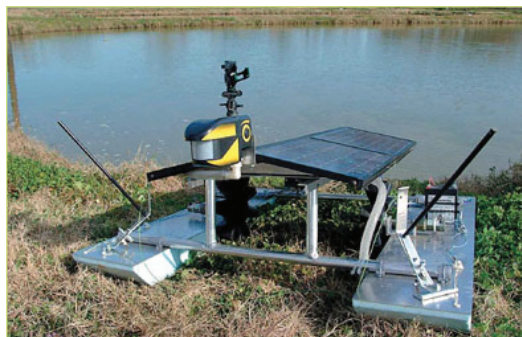
For more information, please visit:

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Website: www.hitecrcd.com



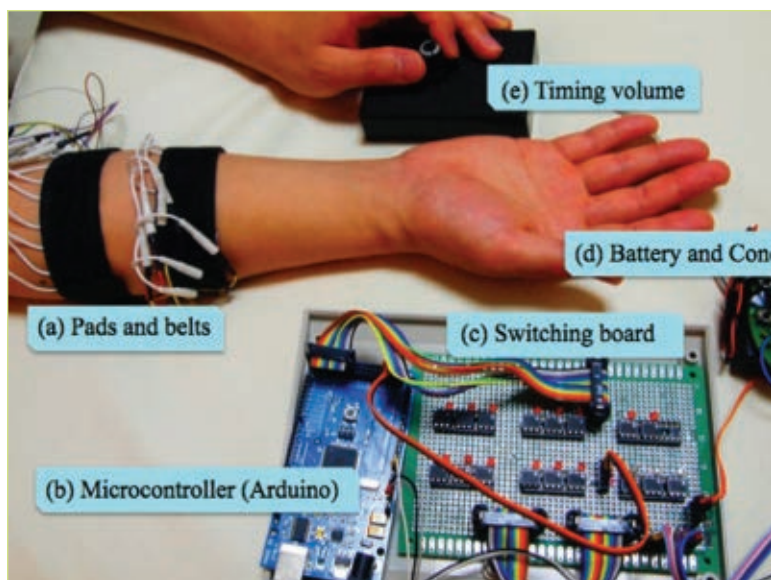
bots IN BRIEF



SCAREBOT FOR THE BIRDS

Steven Hall and Randy Price of the LSU AgCenter have found an answer to the question, "How do you keep predator birds away from growing catfish and crawfish in ponds?" The answer is Scarebot — a robotic boat that is solar powered and drives around at about 5-7 mph. When its IR sensor knows a bird is nearing, it triggers a water canon to chase it away.

The bot recently gained attention from John Cole of Tennessee's Mt. Pelia Innovative Solutions who sees the Scarebot as a good thing and will help fund its production.



HAND POSSESSES POTENTIAL

In an interesting meshing of robotics and prosthetics development, Japanese researchers from Tokyo University working in conjunction with Sony Corporation have created an external forearm device capable of causing independent finger and wrist movement. Introduced on the Rekimoto Lab website, the PossessedHand (as it's called) can be strapped to the wrist like a blood pressure cuff and fine-tuned to the individual wearing it. The PossessedHand sends small doses of electricity to the muscles in the forearm that control movement, and can be "taught" to send preprogrammed signals that replicate the movements of normal wrist and finger movements (such as plucking the strings of a musical instrument).

Though the signals sent are too weak to actually cause string plucking, they are apparently strong enough to cause the user to understand which finger

is supposed to be moved. Thus, the PossessedHand might be construed to be more of a learning device than an actual guitar accessory.

Currently, devices that do roughly the same thing are done with electrodes inserted into the skin, or work via gloves worn over the hand — both rather cludgy and perhaps somewhat painful. This new approach in contrast is said to feel more like a gentle hand massage.

Though the original purpose of the PossessedHand seems to be as an aid to help people learn to play musical instruments — something that has inspired a bit of criticism from the musical community due to the fact that nothing is actually learned when using the device — the Hand basically becomes an external part of the instrument, while the brain remains passive. It seems clear the device could be used in many other ways. For example, it could be used by hearing people to assist in speaking with deaf sign-language users or to help people type who have never learned how. Or, perhaps more importantly to help paralyzed people or those suffering from a stroke.



bots IN BRIEF

TRANSFORMING SCRAP

We've seen our fair share of robot sculptures built from scrap parts before, but these reproductions of Transformers Autobots may be the best yet. Anchalee Saengtai is getting international exposure thanks to Ripley's Believe It or Not which is hosting her work at their odditoriums in Hollywood, New York City, London, Myrtle Beach, and Jeju Island (in South Korea). She and her team have built a 19' (5.7 meter) tall version of Optimus Prime, and an 8' tall Bumblebee using basic tools. The third film in Michael Bay's series hit theaters June 29th.



IDENTIFY YOURSELF

For many employees, an ID card is required in order to enter an office building. Shandong Kang Bai ROBOT Automation Co., Ltd is working with the Harbin Institute of Technology to create industrial manufacturing robots and use these welding robots to produce a friendly robot security kiosk. Standing nearly two meters tall atop its podium, the robot uses a head-mounted camera and face recognition software to let registered employees pass automatically while waving its arm in a stilted greeting.

The first time employees pass the robot, they must confirm their credentials by swiping their ID card. It takes a photo, registers them into a database, and will recognize them automatically from then on. Of course, the kiosk's touch screen can also be used to register employees where businesses haven't already adopted a key card system.



A GEN FOR JOE

Joe Tucker — who lost part of his leg in a motorcycle accident in 1995 — is the proud recipient of a \$95,000 waterproof, bionic replacement.

Although he has tried six other legs, he claims this is the first one to make him feel "able bodied" again. The battery powered prosthetic — known as a Genium — contains a sensory system to help a human walk easily, avoid obstacles, and climb stairs. Unsurprisingly, the German firm Otto Bock built the leg in cooperation with the US military. Joe is one of the first civilians to receive one.

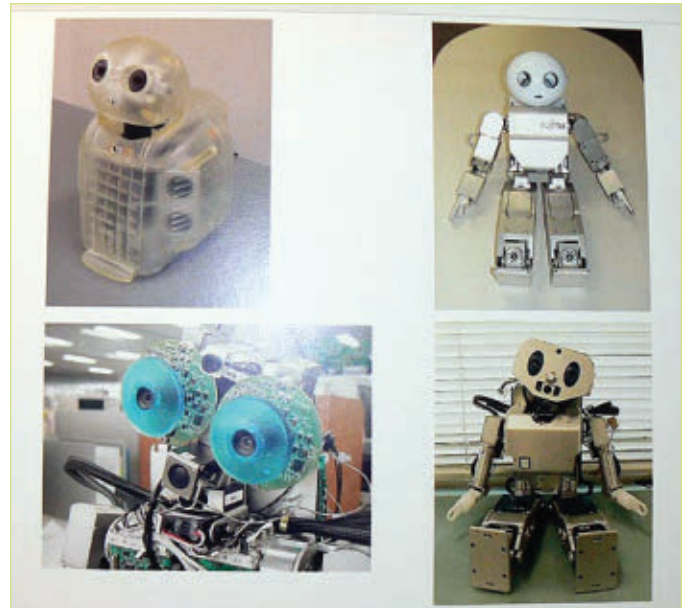


WHAT'S UP WITH Mi-Ro?

This little cutie is a multi-media communication robot called Mi-Ro that was developed by Fujitsu. Mi-Ro was basically a head with stereo cameras attached to a PC base that could be used to study computer vision, among other topics. It's quite possible that it was initially developed to compete with the likes of NEC's PaPeRo, Hitachi's AV Mascot, and Toshiba's ApriAlpha. Details are sketchy at best, but it's clear that some of the hardware components developed for Mi-Ro were fed directly into the third model of Fujitsu's humanoid research platform (HOAP) which was released in 2005.

It's possible that Mi-Ro may be connected to a communication robot from the Kanagawa Institute of Technology (KAIT). The similarities in both aesthetics and capabilities are striking, given the general shape, vent placement, and LED irises that ring the camera eyes. The main difference is that it has rudimentary arms and an LCD touch

screen. KAIT's robot was developed to be a fun partner for the elderly (and to help prevent dementia). Software allowed you to edit MIDI files and add lyrics through a simple touch interface, while a speech synthesizer called SMARTTALK would generate a singing voice. Songs could then be saved and output as WAVE files with robot gestures and expressions synchronized to the beat. Whether Mi-Ro was later adopted at KAIT, and what happened to the software, remain a mystery.

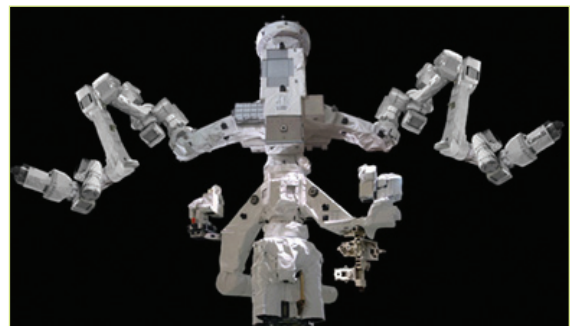


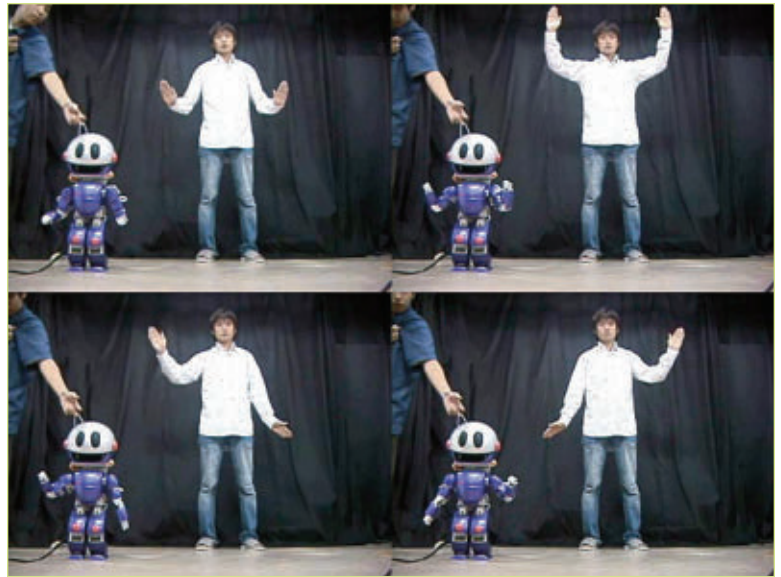
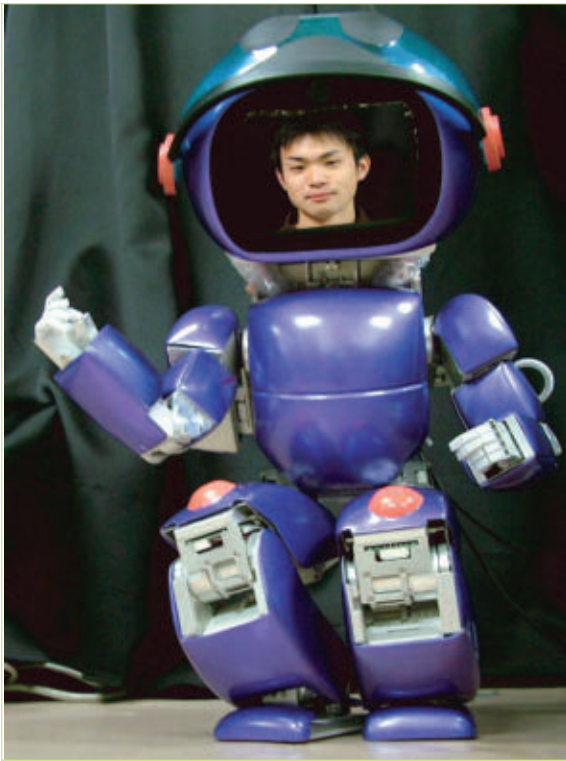
HOPEFUL HUMANOID

Tomotaka Takahashi of Robo-Garage is helping to design a 30-40 cm humanoid to be unveiled February 2012 and sent into space in 2014. To get things started, the Kibo (which means hope in Japanese) Robot Project has its own website where ordinary humans can submit audio recordings and Tweets with ideas for what he should be named and what he should say once he has been sent to the International Space Station (ISS).

FILL'ER UP

When the Atlantis made its final flight last month, it brought a robotic refueling mission along to determine the best way to refuel satellites in space. After Dextre attaches to the exterior of the ISS, the remote controlled filler-up bot will practice by unsealing them, transferring fluid, and resealing them for future use. They are hoping for it to be able to do repairs, as well. If the 12 day RRM is successful, NASA is planning to literally seal the deal by 2013.





PICO GOES STRAIGHT

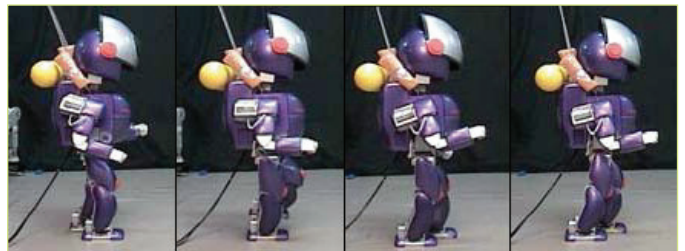
Researchers at Kyushu University decided to modify their resident Fujitsu HOAP-2, and renamed it PICO (proactive interface robot). They added an entirely new head which increased its height to 64 cm (25") and weight to 8.7 kg (19 lbs) and contains a camera, a small LCD screen,

speaker, and microphone. They also rounded out its metallic body with attractive plastic shells.

PICO-2 is one of the few whole-body telepresence robots in existence. The robot's helmet visor can be retracted allowing the LCD screen to display the user's face, and its body reproduces the operator's gestures or even walking and dancing. This research was done in 2005, so they didn't have the benefit of a Kinect sensor, but the general idea is similar and works almost as well. First, the user's body position is extracted from its silhouette in images taken with the monocular camera. It then reconstructs the positions of the arms and legs in simulation using a digital avatar. Finally, the motions of the avatar are sent to be reproduced on the robot in less than 30 milliseconds, allowing non-verbal communication to happen in (almost) real time.

Ryo Kurazume and Tsutomu Hasegawa also wanted PICO-2 to perform straight-legged walking. Bipedal robots often walk with their knees bent, lowering their center of gravity to keep it as steady as possible. This is usually because the joints have a limited range of motion, and it helps to maintain balance. The problem is this looks rather unnatural to us humans (some have described ASIMO's posture as looking like it needs to go to the bathroom).

Surprisingly, only a few examples of straight-legged walking exists in robots (Chroino by ROBO-GARAGE and WABIAN-2 by Waseda University are two other examples). Walking with straight legs doesn't just look more natural; it actually improves the overall efficiency since less torque and energy consumption are required. After some simulations, they applied their strategy to the robot and found that it could walk with straight legs; the energy consumption was cut roughly in half.



ANDROIDS ANYONE CAN OWN

It didn't take long for the Google Android to appear in wind-up form. Now you can get a three-pack in green, red, and black to keep others at home or work annoyed. If you prefer your Android in the dark, there's an Andrew Bell designed key chain that will light up your nights (and even help you find your keys).

Cool tidbits herein provided by Evan Ackerman at www.botjunkie.com, www.robotsnob.com, www.plasticpals.com, and other places.

COMBAT ZONE

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BUILD REPORT:

Another Brick in the Wall – Building Rudy

● by Thomas Kenney

In mid 2009, I built the most recent version of my Ant brick, Gilbert. Since then, the robot has won nearly every event it's competed in, placing second in the one odd exception. The wedge and frame design are well proven, but I still have the problem of losing one of the near-extinct 13 mm 17:1 Maxon gearmotors every few events. With all this in mind, at the beginning of the year I started to draw up a prospective replacement bot with a near identical frame and compatible wedge mounting structure. The main difference in design was switching drive motors from the rare Maxons to a

set of Fingertech Robotics' prototype 'Silver Spark' gearmotors.

The machining process itself differed from Gilbert's construction. With that original frame, I had just added .75" or so of extra material onto each side of the UHMW block used for the frame. The piece was secured to the mill bed through these ablative sections which were lopped off on the table saw after machining was completed.

Now that I have a larger mill

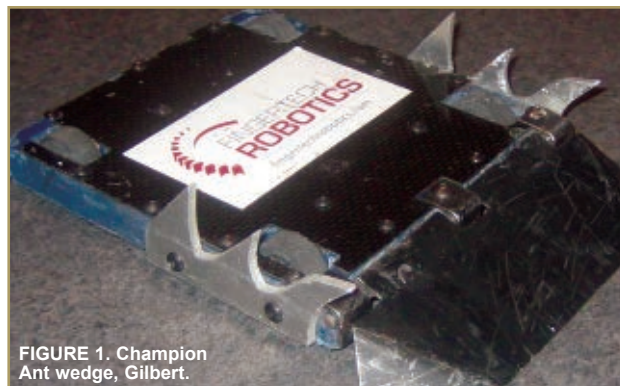


FIGURE 1. Champion Ant wedge, Gilbert.

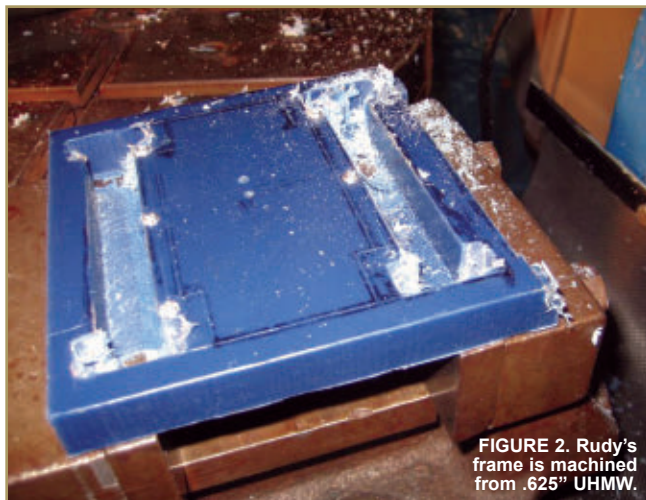


FIGURE 2. Rudy's frame is machined from .625" UHMW.

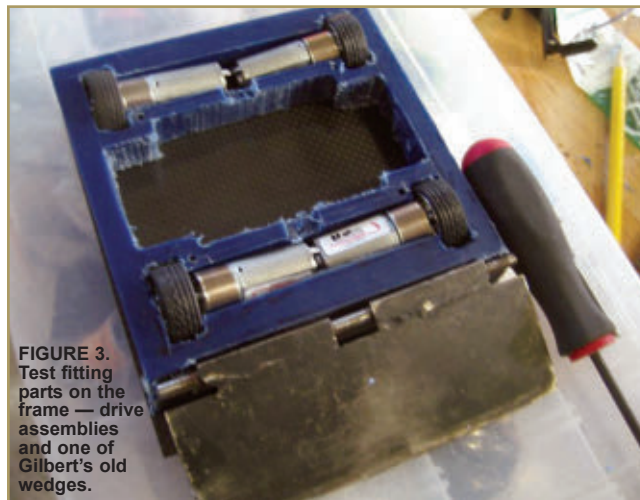


FIGURE 3. Test fitting parts on the frame — drive assemblies and one of Gilbert's old wedges.

that can actually travel the full length of the frame, I eventually decided to go with a simpler route that wouldn't require me to remove, reattach, and re-indicate the frame piece more than once, if at all. I found a spare piece of .5" aluminum, squared off all the edges, and drilled and tapped six 4-40 holes at precise locations.

I took the UHMW block the new frame was being made from and screwed it into this jig with the six screws passing through the material that would eventually become the frame's two inner rails. The placement of these mounting screws made it possible to do all the major cutting without having to rearrange any mounting since the end mill just passed around the screw heads.

Apart from the time spent putting this new method together, the machining itself went smoothly. After mounting the main piece, the thing to be cut down was the material thickness. Built for the square motor slots to have a snug fit around the Spark gearmotors, the frame thickness was designed to be .625". I had .75" thick UHMW on hand; the thickness tolerance on UHMW stock tends to be fairly ridiculous, usually clocking in at about $\pm .1$ ". I brought the cutting tool down to the correct height and ran it across the UHMW, removing the mounting screws as it passed by, then reinserting them on the

thinned material. With the material now the proper thickness, it didn't take any more than half an hour to cut out the remainder of the frame's features.

As stated, the frame itself was similar in most aspects to its predecessor's — more compact overall and now featuring 3/8" side walls. It had the same wedge blocks on each side of the frame, omitting the center piece for weight and simplicity's sake. These blocks were accompanied by the usual set of bent and hardened .06" 'wedge clips' to secure the steel shaft welded to the wedge.

The matching wedge mounting setup allowed us to just use some of Gilbert's alternate wedges rather than welding together a completely new part. (More details on the wedge setup used can be seen in my July '10 *SERVO* article, 'A Reintroduction to Wedges').

Last, the robot was given a set of Gilbert's spare 'horned appendages' to use for pushing non-active weaponed bots around, as well as giving the brick some sort of cool factor.

Most of the electronics used were a relatively

standard Ant setup, featuring a pair of v2 TinyESCs and a small Spektrum DSM2 receiver. The only defining feature in this aspect was the eventual upgrade to a full five cells (18.5V nominal) of 250 mAh LiPos in order to get as much speed out of the drive motors as reasonably possible.

As of this writing, Rudy has had more than a few minutes in the arena. Though it has a relatively mediocre record due to some issues with improperly chosen wedges and untightened screws, the new Silver Spark gearmotors have held up perfectly despite taking more direct hits than some of Gilbert's Maxons ever did.

I'm more than satisfied with the bot's basic performance. Rudy is more than ready to take over the mantle of MH Robotics' Ant wedge flagship once Gilbert's spare Maxons eventually run dry. **SV**

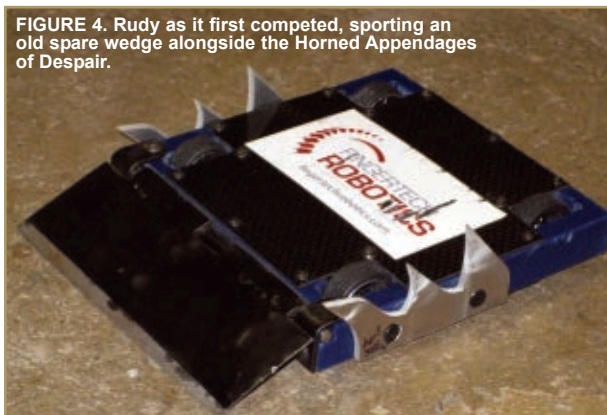


FIGURE 4. Rudy as it first competed, sporting an old spare wedge alongside the Horned Appendages of Despair.

BUILD REPORT: Building a Better Beetle Beater Bar!

Part 2 – The Axle and the Pulley

● by Pete Smith

In Part 1, I showed how to machine a simple and cheap beater bar for a 3 lb Beetleweight combat robot. This month, I will show how to create the axle, drive pulley, and flanges.

The axle used in my Weta kits is a 5/16" ground titanium shaft. This is much lighter than a steel shaft, and has proved to be stiff and strong enough to survive many fights without failure. I buy the stock shafting from www.mcmaster.com; their part number is 89055K341. This provides a ground surface for the needle roller bearings to run on (most needle roller bearings – unlike ball bearings – run directly on the shaft surface) and is reasonably cheap for the small size required.

The first version of Weta used shaft collars to retain the axle, but these proved to be very vulnerable in combat and nearly cost us a couple of fights when they failed to

hold the axle in position. The solution was to thread the last 5/8" or so of both ends of the axle and use washers and locking nuts to keep everything solidly in place.

Safety Note: Lathes are dangerous if not used correctly. Remove jewelry, any loose items of clothing, and ALWAYS wear safety glasses.

I first cut the axle to length using a cut-off tool and then machined the external diameter down to the correct size for the external thread being used. I have a set of metric threading dies, so I chose the right size for an M8 thread.

Threading titanium is tough, so you may want to make the diameter a little undersized so that it's easy to thread. I've found that even a 50% thread height still works well. Machining a small piece of titanium is more difficult than it is for most materials. It's hard but springy, and

will tend to simply bend away from the tool. It took a lot of passes to finally get it to the desired diameter over the length required (**Figure 1**).

I've found a good lead-in for the die helps, so I created a sharp point (**Figure 2**) on the end of the shaft to form one. It not only looks good, it also makes the bot less likely to stay balanced on its side in a fight. Repeat the above for the other end of the shaft.

The axle is then held vertically in a bench vise. I protected its ground surface with a thick layer of paper towels, but if possible get a set of soft jaws or similar as I have damaged shafts even with the paper.

A hardened steel die is used to create the external thread (**Figure 3**). Take your time and use plenty of lubricant, and you can form a nice thread (**Figure 4**).

A drive pulley is required to power the beater bar. I have found

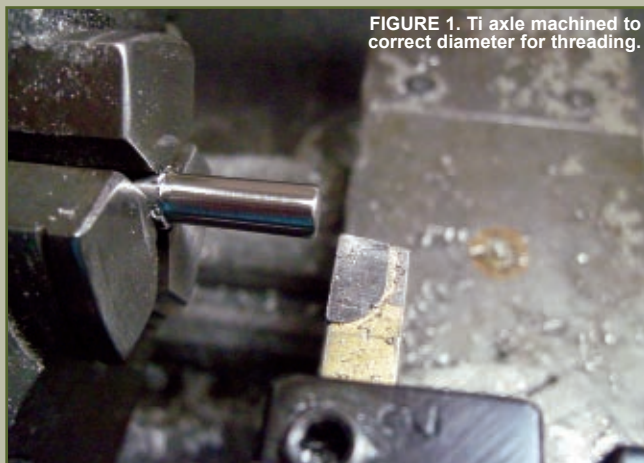


FIGURE 1. Ti axle machined to correct diameter for threading.

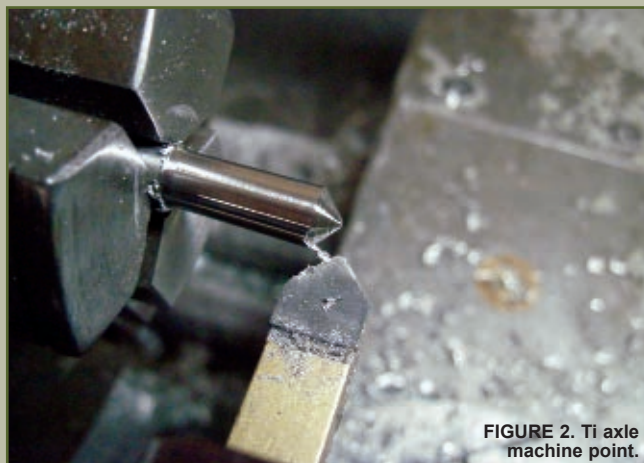


FIGURE 2. Ti axle machine point.

FIGURE 3. Ti axle using a die to thread.



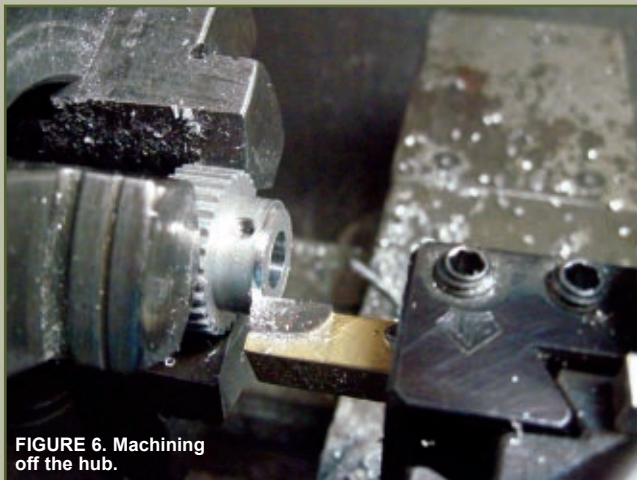
FIGURE 4. Ti axle threaded with nut.



FIGURE 5. Drilling out the pulley.



FIGURE 6. Machining off the hub.



that 3 mm pitch HTD x 6 mm wide belts work well in Beetle class bots. A good source for pulleys and belts is www.sdp-si.com. You can also get custom pulleys from www.fingertechrobotics.com.

On the original version of Weta, I used a 40 tooth pulley. I have since moved to the 30 tooth shown in the

downloadable drawings from the article link.

You can buy pulleys with stock flanges, but they are not very deep, are made of soft aluminum, and are easily damaged. I wanted to have deep flanges that would not allow the belt to easily jump off the pulley and flanges that could take a light

hit and keep functioning.

With this in mind, I designed two simple machined UHMW flanges that would be retained by the same screws that mount the pulley. It's also important that the attached pulley is on the same axis as the axle, but not actually touch it.

To ensure this, the assembly is

FIGURE 7. Pulley and flange on bearing.



FIGURE 8. Pulley on beater bar.

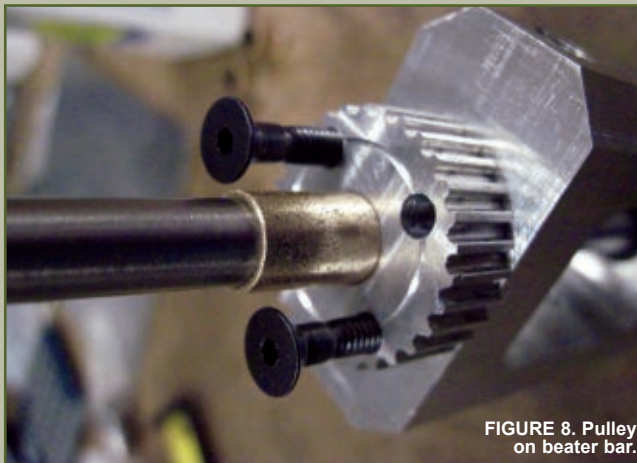


FIGURE 9. Finished assembly.



FIGURE 10. Alternative teeth.



built around a bronze sleeve bearing with a 5/16" diameter bore (to suit the axle) and a 3/8" outer diameter. I used McMaster part 6391K156.

The flangeless pulleys from SDP-SI usually come with a large hub and a steel setscrew. Remove the setscrew and then secure it in the lathe chuck by gripping the hub (Figure 5).

A 3/8" drill is used to drill out the bore of the pulley to match the bearing. The part can then be turned around and the hub removed (Figure 6).

Mark out and drill the two mounting holes. These don't have to be too precisely located since the bearing will control the position of the pulley relative to the beater bar.

The flanges are machined from 1.75" UHMW round bar; they have a 3/8 center bore and generous chamfers to help keep the belt on. The mounting holes in the flanges

are added by mounting one of them at a time onto the bearing with the pulley and then marking the centers of the mounting holes using a transfer punch and the pulley as a guide (Figure 7).

Drill one hole at a time and use a 8-32 screw to align those holes while you use the transfer punch to mark the center of the second hole. Similarly you can use the axle, bearing, and the pulley to position the mounting holes in the beater bar (Figure 8).

Remember to position the mounting holes in the bar so that they avoid the holes drilled for the teeth, and protect the roller bearings (I use pieces of duct tape) from any metal swarf or other contamination when drilling and then tapping the holes.

Finally, attach the pulley and flanges to the beater bar using two 8-32 x 1.25" steel flat head screws

(McMaster part 91253A201) with the sleeve bearing still in place.

Use a little loctite on the threads (be careful not to let any get in the roller bearings), and when the screws are both tight remove the sleeve bearing. If it's tight, use a pair of pliers.

Remember to also use loctite on the teeth threads as well to prevent them from working loose in testing or during a fight.

The finished assembly (Figure 9) weighs about 10 oz and is available already built on the Kitbots website (www.kitbots.com) as a stand-alone option for the 3 lb Crum Beetle Chassis kit.

The same basic design can be modified (if desired) to use separate hardened steel teeth (Figure 10), but this is a lot more work and expense.

The beater bar was first used in combat at Motorama 2010. **SV**

EVENTS

Upcoming Events for August – September 2011

The Homebrew Robotics Club will present their TABLEBot Phase II Challenge at Google (1400 Crittenden Lane) on August 31st. Phase III will be held on October 26th. Go to www.hbrobotics.org for more information.

House Of Robotic Destruction 2011 will be presented by the Ohio Robot Club at the Classic RC Raceways in Akron, OH on September 17th. Go to www.ohiorobotclub.com for more information. **SV**



EVENT REPORT: Mid-American Melee

● by Michael Winek

The Mid-American Melee — the first event hosted by the student chapter of the American Society of Mechanical Engineers (ASME) at Washington University in St. Louis — was a smashing success.

Three Fairy weight, six Ant weight, and nine Beetle weight combat robots went head-to-head in a newly built 4' x 8' x 2' arena with 1/4" polycarbonate walls and ceilings, and a 2' x 1.5' trapdoor equipped with a drop box to catch fallen robots.

Three robots entered the Fairy weight division: a vertical bar spinner named Blond Redhead; a flipper dubbed Old Guy; and a solid wedge ironically called Snorlax. Throughout the round robin series of fights, Blond Redhead's spinner produced strong gyroscopic forces which pulled the bot around the arena, allowing opponents to easily push the hapless robot through the opened trapdoor. Ultimately, Snorlax took 1st place, followed by Old Guy with 2nd place, and Blond Redhead with 3rd.

The Ant weight round robin tournament showcased an impressive array of creative designs. Highlights included Cup Bot — an undercutter with a body based around an athletic cup — and its greatest opponent, Slash — an overhead bar spinner acting as the flagship robot for Titan Tech Robotics.

These two bots wreaked havoc through the brackets, repeatedly removing wheels and breaking axles. In an exciting match, Slash dismantled the lifting arm of Emoticon — a flipper built from an aluminum can. Despite Cup Bot and Slash's highly destructive



capabilities, they finished 2nd and 3rd, respectively, with Emoticon taking 1st place.

The Beetle weight division was fought in a double elimination bracket. The bout started with several high kinetic energy weapons that effectively destroyed both their opponents, as well as themselves. Bananas — an undercutter with an intimidating hooked bar — and Rainbow Road — a wedge equipped with rubber conveyor belts — produced the most memorable match, during which Bananas won the hearts of the audience by using its eight ounce, steel-tipped spinning horizontal bar to smash the wheels off of Rainbow Road.

Can Of Nuns (C.O.N.) — a dustpan robot with a large clamping arm — advanced through the winner's brackets undefeated, and



took 1st place by sweeping up, holding down, and depositing its opponents in the drop box after the trap door opened. Second place went to Big Bladed Bastard (B.B.B.) — a rock-solid brick with a metal-plate "blade" in the front — and 3rd place to Bananas, to the audience's disappointment.

After the tournament, all the working robots entered the arena again for a melee event in each

weight class. C.O.N. conquered the Beetle class melee, taking control over any who dared approach it. Front Wedgie (a wedge) unexpectedly won the Ant division melee after most of the other bots had fallen through the open trapdoor. Blond Redhead came out

on top in the Fairy division melee after Snorlax flipped over and got stuck near the trap door. The Mid-American Melee culminated with awards for all the tournament and melee winners. The event organizers thank FingerTech Robotics and Basic Micro for generously providing the

prizes. First place finishers received a two channel electronic speed controller appropriate for their weight class from Basic Micro; second place finishers won LED bars from Basic Micro; and third place finishers received gift certificates to FingerTech Robotics. **SV**

EVENT REPORT: National Robotics League Championship

● by Kevin Berry

Twenty-nine robots built by 91 students from 14 schools battled for national recognition in two days of intense competition at the National Tooling and Machining Association's (NTMA) 2011 National Robotics League (NRL) Championships held May 21-22 at Vincennes University's Aviation Technology Center in Indianapolis, IN.

Bloomsburg Area High School's Pixie received the highest overall score as a result of a combination of points earned through the robot's performance and documentation submitted with the robot, and was declared the 2011 NRL National Champion. The school was awarded a \$500 check from the NRL to support the robotics program.

NTMA is a national association representing nearly 1,300 companies in the precision custom manufacturing industry. The organization founded the NRL to challenge misperceptions about manufacturing, and to attract students to high paying technical careers. The program partners teams of middle school, high school, and post-secondary school students with local NTMA manufacturers who work together to build machines designed to test ingenuity and do battle.

The result is the creation of incredible 15 lb robotic machines and fun and exciting events, all while building high tech skills and sparking the interest of students about careers in manufacturing.

The bleachers were packed with cheering fans watching rounds of metal-crunching competition in the plexiglas arena.

A volunteer panel of three judges from the Indiana Chapter of the NTMA scored each round, with points awarded for combat and engineering. NTMA Board Chairman Grady Cope, CEO of Reata Engineering & Machine Works in Englewood, CO presented trophies to the 1st, 2nd, and 3rd place teams.

"The large numbers of students, parents, teachers, and volunteers that the NRL brought together exceeded our expectations," said NTMA Vice President and Chief Operating Officer Rob Akers. "The NRL program is one of the best

University of South Florida Robots Interest Group with The Brain – 1st Place.



Bloomsburg High School Team Malicious Intent with Pixie – 2nd Place.



Venango Technology Center Team Mayhem with Khaos – 3rd Place.





Sparks fly as machines crash in the arena.



Getting student's hands inside precision machinery is the NMTA's goal.

mechanisms we have found to attract students into our industry and teach them about the highly technical, well-paying career opportunities in manufacturing."

Bloomsburg also received recognition for "Coolest Robot" (Excessive Force) by a vote of all the student participants. Competition judges awarded Fayette County (Georgia) Area Vocational Technical School a certificate for "Best Documentation" for their Grim Reaper III robot, and the University of South Florida Robotics Interest Group's The Brain was awarded 1st place in the day's competition.

"One of the most educationally effective components of the weekend was the professional review of the engineering documentation and personal interviews with the student teams," said Michael Bastoni, coach of the Plymouth (MA) North High School Team. "This represents 'Best Practices' with respect to project-based learning and authentic



Vincennes University's Aviation Technology Center provided an impressive venue.

assessment, and was a particularly beneficial experience for the student designers and builders."

The NRL Championship was sponsored by DMG/Mori Seiki, Grainger, and DS SolidWorks.

The top three finishers in the robot battle competition:

- 1st Place: University of South Florida, Tampa, FL
Team: USF Robotics Interest Group
Robot: The Brain

- 2nd Place: Bloomsburg Area High School, Bloomsburg, PA
Team: Malicious Intent
Robot: Pixie

- 3rd Place: Venango Technology Center, Oil City, PA
Team: Joy Manufacturing
Robot: Chaos

For more information, photos, and competition videos, visit [Facebook.com/gonrl](https://www.facebook.com/gonrl) or contact Caitlin Andrews at caitlin.andrews@bgllp.com. **SV**

Dust in the Wheels

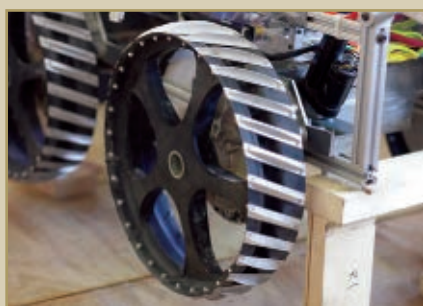
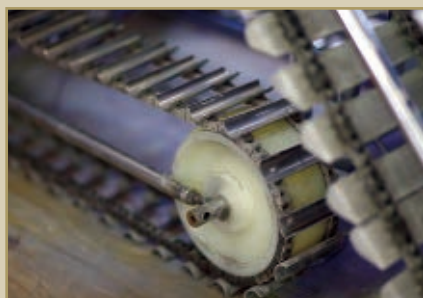
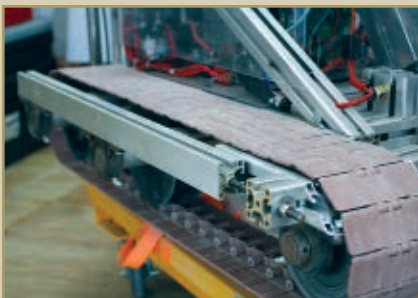
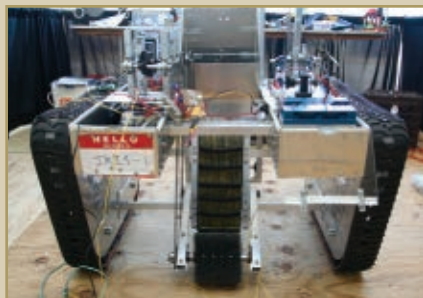
● by Kevin Berry

With apologies to the band, Kansas:

*Dust in the wheels ...
All they see is dust in the wheels.*

One of the things I spent a lot of time looking at when reporting on Lunabotics 2011 was wheels. This — along with my irreverent reference to mellow 80's music —

may sound trivial. However, taking robots into the real world is a non-trivial exercise. The simulated regolith — or lunar soil — used in this competition is a viscous, vicious,



nasty medium for robotic propulsion. Think of a swimming pool full of dry ready-mix concrete. Talcum fine gray dust mixed with aggregate and occasional large chunks provides a worst case traction problem.

Having attended both the 2010 and 2011 event, I quickly understood the challenge provided by this dusty nastiness. The extremely fine, abrasive powder got into every bearing, electronics box, and mechanical joint. Bots routinely buried their wheels in deep ruts, with no hope of self-extraction.

Anything with treads or mesh was quickly clogged. Anything



to the question: "What's the best way to move a bot in fine dust?" Well, like all real world situations, there is no clear answer. So many failure modes exist in a competition like this, that for some teams

smooth slipped like a car on ice. Those trying to use large cleats found they'd perfected a technique to bury their machine quickly.

Treads seem like the obvious answer to this dilemma. However, that pesky need to steer means that a tank drive system is needed. Turns out, treads dig trenches even better than wheels!

I would like to conclude this brief article by giving a clear answer

traction was the least of their problems. Or, seemingly identical bots performed completely differently.

So, the best I can suggest is: experiment, improve, experiment more. The only statistically significant correlation is that teams that practiced a lot, did better. Teams that built at the last minute, not so well.

Q.E.D. **SV**

EVENT REPORT: NASA Sp[🎯]nsors 2nd Year of Lunabotics Competition

● by Collin Berry

Lunabotics is a NASA sponsored competition for college students to design a robot that could be used for lunar mining. The main goal of the event is to promote science, mathematics, problem solving, and engineering in the classroom. Twelve teams came from around the world to join 32 domestic teams for a chance to compete in the “sandbox”

of simulated lunar soil, or regolith. The event this year took place in the Rocket Garden at Florida’s Kennedy Space Center. The robots are designed to move as much simulated moon dirt as possible in an allotted amount of time. Simply put, the team that moves the most dirt in weight wins. **SV**



The Kennedy Space Center's Visitors Center provided an impressive venue for this year's Lunabotics competition.



Much like a piece of modern construction equipment, the robot from Virginia Tech used a scoop design. Robots have to dig from one area of the playing field, and then deposit it at the other end. The dirt is weighed as it's collected.



The “bucket drum” is what makes the Prescott, AZ campus of Embry Riddle Aeronautical University's design one of the more unique robots. As the drum spins, dirt is collected inside. When the time comes to dispense the dirt, the drum spins in the opposite direction which empties the drum.



The team from BRAC University in Bangladesh faced a unique set of problems when designing their robot. Because they don't have a large amount of robot supply stores in their country, most of their parts came from junk yards. They used windshield wiper motors to move their robot, and scrap metal to build the chassis.



Teams operated their robots from the Desert Rat's control van. They watched via a video camera mounted high in the competition tent. Many teams did attach a webcam to their robots for better control. Several teams used video game controllers to maneuver their robots.



University of North Dakota's robot featured a scoop made from carbon fiber. They opted for carbon fiber as a way to save weight which allowed them to move more dirt at a time. An aircraft manufacturer (Cirrus) made the scoop. Another sponsor was an auto shop which can be seen in the professional paint job.



The Laurentian University robot's design was one of the more common designs. There is a series of scoops mounted on a belt. As the belt rotates, dirt is scooped into a hopper. The hopper is then dumped in the collection area.

In Front of the Cameras at RoboGames

● by Sam and Liz McAmis

This year, we competed at RoboGames with our heavyweight, Gruff. Since Gruff had competed at the Combots Cup V, we had been contacted early by the production company that would be producing the "Killer Robots" show for the Science channel. We had already given them a bit of information about our robot, but we really had no idea what to expect once we got there. Though our teammates in the USF Robotics Interest Group brought four other robots to the event, the TV crew was only interested in the heavyweights.

Safety inspections at RoboGames arrived without much fanfare. Everyone had to be there Thursday and checked in by 11 pm. Around 6 pm, a woman in a noticeable scarf started coming to builders asking for their time and a photo shoot of their heavyweight. While she was known by builders who had previously done shoots at

Grant was briefed on the robots in between fights.



their shops, those of us who had not met her slowly realized that the woman with the scarf was the director of the TV crew and started to line us all up for the photo.

Each heavyweight robot was led into a dark room with a pedestal. A few minutes went into setting up the robot, and the ensuing small talk about what the robots actually do and some of their back stories.

The robots were then photographed while spinning around a couple of times on the pedestal. Multi-bots like Death and Taxes had to do separate shots for each robot. Safety inspections were still going on after the photo shoots, and many robots were waiting for time in the arena, since it had only just been completed. The TV crew seemed very surprised by the builder's comments on the fact that many of them would be there all night making sure everything was working properly for the competition in the morning.

Friday morning came around, and Simone Davalos (Dave Calkins' wonderful partner in crime and the person most visibly in charge of the combat event) gathered all the builders for a safety meeting. In the process, the producer was introduced and he talked to the builders about what was to happen. They revealed that the double elimination tournament would be portrayed on TV as a single elimination bracket for the Killer Robots premiere, "Because the general public would find a double elimination too hard to follow within the time frame we have allotted."

Most drivers assumed that a



Multiple cameras both inside and outside the arena caught the action.

reasonably similar bracket of the matches will be constructed. Some spent a bit of time wondering what could happen if someone climbed the loser's bracket, but all in all everyone was very excited about finally having robots in the spotlight again. To have your robot show up on TV, to have that brief moment of camera time, made it worth it.

The first fights of the day were the Featherweights — not involved directly with the televised portion of the competition. However, in order to practice the fluidity of the motion and to get some phrases from the builders as the day went on, Featherweight drivers were hooked up to the microphones.

As the result of a schedule mix-up, Liz had to be wired up three or four times. The sound crew was nice and friendly; over the course of the weekend, they continued to remember your name and robots. The director was ever present throughout the many fights, being kind to drivers even when things were out of their control. The video cameramen got to know everyone,

as well. They really seemed to appreciate the matches they were recording and would let you stand by them to video your matches as long as you didn't get in the way.

As the weekend progressed, Grant Imahara of Myth Busters fame appeared. So did the mob. Many people swamped him as soon as he wasn't rolling with a camera. Grant competed in BattleBots with his robot "Deadblow" and even wrote a book on building combat robots, though some of the other builders still remember him as just a "kid" from the BattleBots days.

The producer provided Grant with information about the robots before the match and he, in turn, provided a live commentary of what was happening in the matches. As the weekend progressed, he also started following competitors to their pit after a match to do a post-fight interview. Grant was nice to the builders and crowd; he signed everything from name badges to our robot.

Cameramen added more cameras throughout the weekend. Some bots had them bolted on for an up-close view of the action. The

arena had cameras posted on the walls, in the top corners, and other various places that looked like they would be impervious to robot carnage. Approximately six cameras were mobile, focusing on drivers and following robots. About another nine cameras were in stationary positions inside the arena that could be switched between during the editing process later on. A camera crane appeared overnight Saturday to get big shots of the arena and crowd.

Sunday began strangely with the recording of the show intro, and then the semi-finals and finals matches. The heavyweights ended with a spectacular match between Last Rites and Sewer Snake. After all the time encouraging crowd cheering, recording fights, and builders, the camera crew was done.

As parts of the Convention Center emptied out and the last sets of awards were given, the last fight of the day was not the massive 220 pound robots that everyone came to marvel at.

The builders and the few crowd



A camera crane was brought in on the final day to shoot the intro.

members remaining waited for battery recharges and hasty repairs to see the final appearance of robots at RoboGames 2011. The 60 pound fight between Biohlo and Hotstuff was just as energized a match for those left as the last fight of bots almost four times their size.

Overall, the addition of the film crew didn't change the flow or the friendly atmosphere of the competition. As this return to television brings a new crop of builders and new resources, we hope the feel of the competition stays the same ... just bigger and better. **SV**



So, a Spinner, a Wedge and a Drumbot walk into a bar ...
Hey, is this thing on?
Anybody out there?

Melty Brains by Kevin Berry



Interesting Historical Fact:
An unfortunate case of dyslexia led to a failed, first TV pilot. Luckily, Treg and Goy eventually figured out the problem.

I thought this was going to be about D-Day.

What kind of fighter plane is that?

Let's see you shoot something!



Maker Breaker: The Scoop on Robotics at the Bay Area Maker Faire 2011!

www.servomagazine.com/index.php?/magazine/article/august2011_Intermaggio

by Greg Intermaggio

This year's Bay Area Maker Faire was as big and cool as ever! Tens of thousands of visitors flocked to the San Mateo fairgrounds to do everything from hear Mythbuster Adam Savage talk about how literature has affected his life to participate in a gargantuan swap meet. Here's a quick wrap-up of some of the robot-specific exhibits.



Adam Savage

Okay. He may not be a robot per say, but he did dance in a metal cage while thousands of volts of electricity surged through it. That counts for something, right?!

As has become a custom at Maker Faire, everyone's favorite Mythbuster made an appearance and made an excellent and eloquent speech on how literature has shaped who he is today.

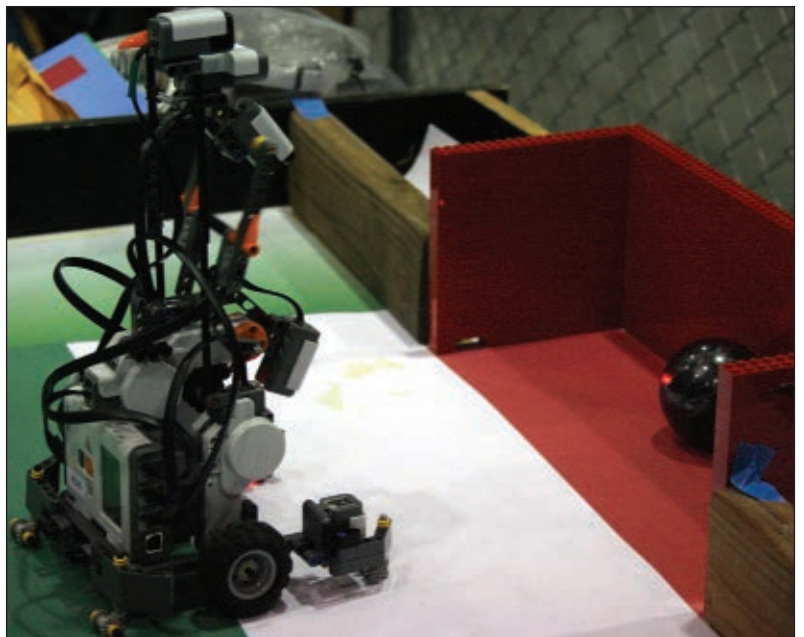
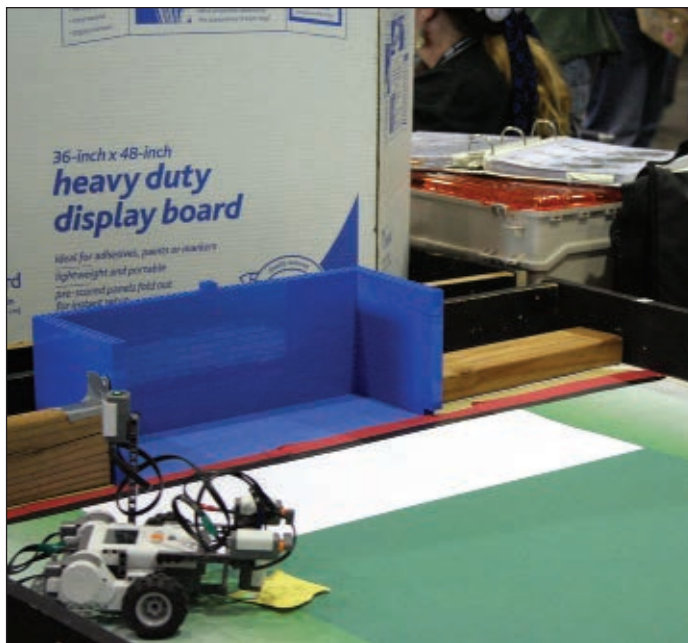
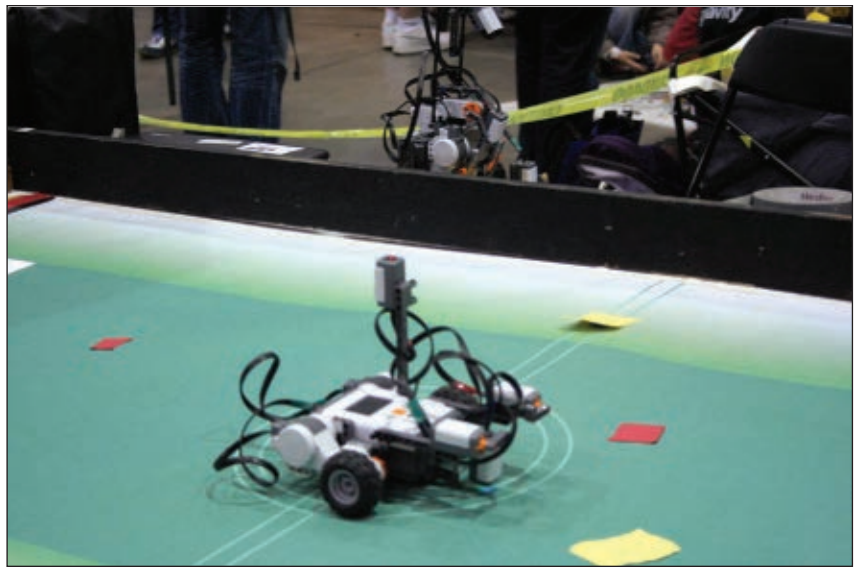
At the conclusion of his speech, Adam stepped into a metal cage and danced to the Doctor Who theme song played by Arc Attack's Tesla coils.

LEGO MINDSTORMS

Also in the Expo Hall near the FIRST booth were Steve Putz and Eva Carrender — two of the biggest names in LEGO MINDSTORMS in Northern California.

Steve is well known in the South Bay for his summer camps and other LEGO robotics programs. Eva is a co-founder of FIRST LEGO League in Northern California, and has an extensive background in LEGO robotics.

Together, Steve and Eva brought an assemblage of LEGO robots to the table that performed a variety of cool tasks, including infrared LEGO soccer.



FIRST

FIRST (or "For Inspiration and Recognition of Science and Technology") had a strong presence at the Faire this year. The international robotics competition was founded in 1992 by Dean Kamen — the brilliant inventor behind the Segway.

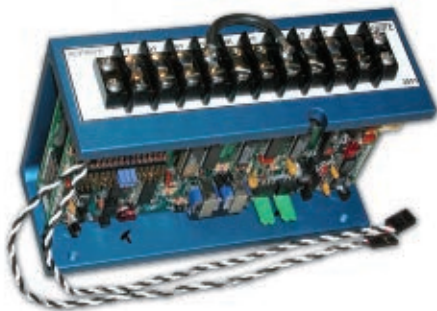
This year at Maker Faire, FIRST's booth showcased 2011's challenge called "Logo Motion." The challenge broke down like this:

- Three robots per team, two teams per match.
- Robots operate autonomously for 15 seconds at the beginning of the match, during which time they attempt to lift "Ubertubes" onto metal pegs.
- After 15 seconds, teams have a full two minutes to control their robots directly and attempt to hang the Ubertubes (and additional FIRST logo pieces) on the pegs.
- At the end of the two minutes of operator control, each robot deploys a minibot. The minibots race to the top of their respective poles to score more points for the team.

A variety of FIRST robots were on display, and several teams were even allowing test drives.



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DIY Drones

For those of us (let's face it, all of us) who have always wanted to make an autonomous flying robot but never knew where to start, DIY Drones brings us a great solution. Roughly 15,000 developers contribute to the project, making it easy for someone with no previous experience to get up and running.

DIY Drones are open source and range from airplanes to helicopters to quadcopters. They use a variety of sensors including GPS for navigation.



THAT'S A WRAP

As always, the Maker Faire was a massive event, and while I attended both full days, I still managed to miss plenty of awesome robots (not to mention non-robots).

If you saw a sweet robot at Maker Faire, I want to hear about it! Drop me an email at g.intermaggio@gmail.com. Until then, enjoy the summer days! **SV**



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PennBots Is Alive and Well!

by Dave Graham

www.servomagazine.com/index.php?/magazine/article/august2011_Graham

PennBots — the Robot Club of Central Pennsylvania, located in Boiling Springs — partnered with Harrisburg University and the National Electronics Museum this spring to bring both fighting and maze solving robot competitions to these two new venues. You can follow PennBots on their website at www.pennbots.org.

Downtown Dogfights

Robot enthusiasts converged at the Harrisburg University campus on March 26th for the first “Downtown Dogfight” and maze solving robot competitions. The fighting robot competition drew local competitors, as well as participants from both upstate Pennsylvania and upstate New York. Seven competitors (**Figure 1**) and their 14 Insect Class fighting robots competed in the 150 gram Flea (a.k.a. Fairy), one pound Ant, and three pound Beetle weight classes. The PennBots arena with its two open pit hazards proved to be a challenge for all drivers.

Bill Bechtel took first place in the Flea weight with his four wheel drive bot FleeWee (**Figure 2**); Kyle Singer dominated the Ant class with Fangus (**Figure 3**); and the youngest competitor, Nick Barber — a member of the

Boiling Springs Middle School Robotics Club — won the gold in the Beetle weight fights with his hacked RC toy robot Demonator (**Figure 4**). The complete list of winners is shown in **Table 1**.

The maze solving competition at Harrisburg University had nine competitors, including a team from Gettysburg High School, and seven maze solving robots (**Figure 5**) sporting LEGO NXT, BotBrain, VEX, and BoeBot engines. Each bot made three runs through a random maze. Pat Woodburn’s LEGO NXT powered robot The Wall (**Figure 6**) took first place with a time of 57 seconds, and Fred Young placed second just two seconds behind. Third place winner and youngest competitor Christopher Smith received a special award for his BoeBot creation named BOW (**Figure 7**). The special award was presented in recognition



FIGURE 1.



FIGURE 5.



FIGURE 2.

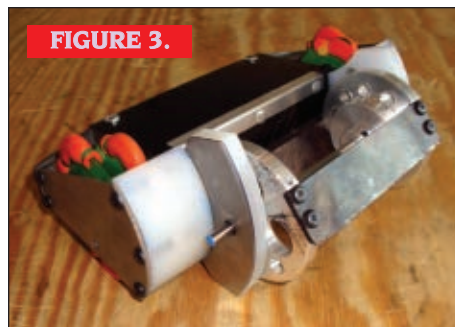


FIGURE 3.



FIGURE 4.

of the fact BOW was the only robot using ultrasonic sensing and never touched the maze walls. Unfortunately, maze solving robot mentor Bill Bechtel couldn't get it done with his robot — accurately named Loser — which decided to climb the maze wall rather than navigate it (**Figure 8**)

Hack-A-Bot

PennBots partnered with the National Electronics Museum in Linthicum, MD, on April 9th to conduct two

	Flea	Ant	Beetle
1st Place	FleeWee Bill Bechtel	Fangus Kyle Singer	Demonator Nick Barber
2nd Place	POS Dave Kelley	Bigfoot Heath Hill	Cleanup Dick Kelley
3rd Place	Brutus Dave Graham	Snaggletooth Dave Graham	TopsyTurvy Bill Bechtel
Table 1. Downtown Dogfight Winners.			

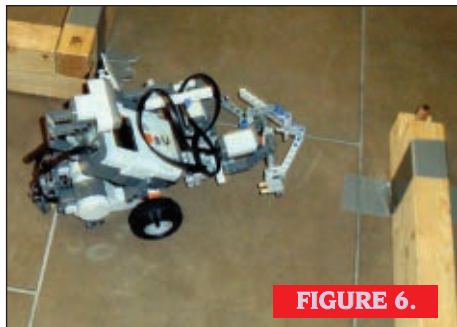


FIGURE 6.



FIGURE 7.

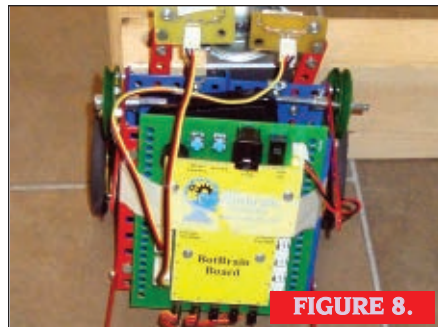


FIGURE 8.

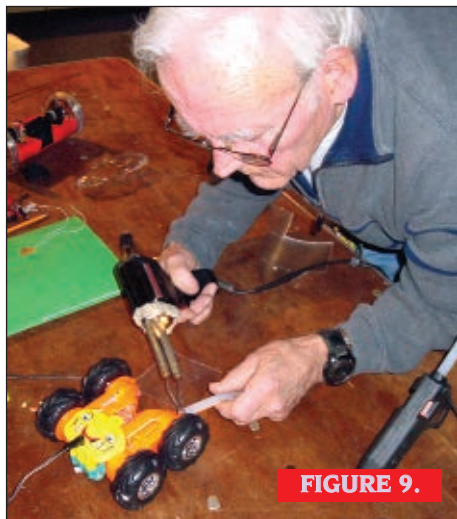


FIGURE 9.



FIGURE 10.



FIGURE 11.

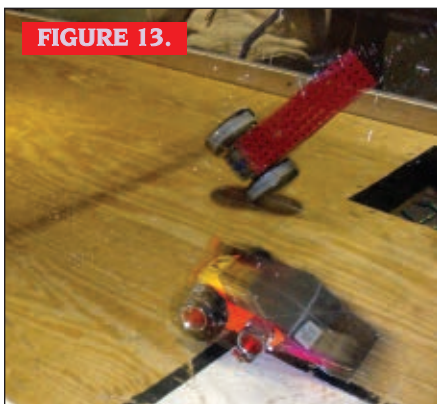


FIGURE 13.



FIGURE 14.



FIGURE 12.



FIGURE 16.

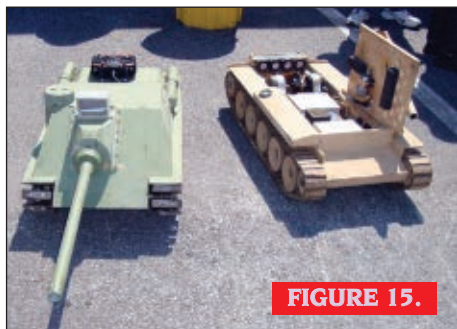


FIGURE 15.



FIGURE 17.



FIGURE 18.

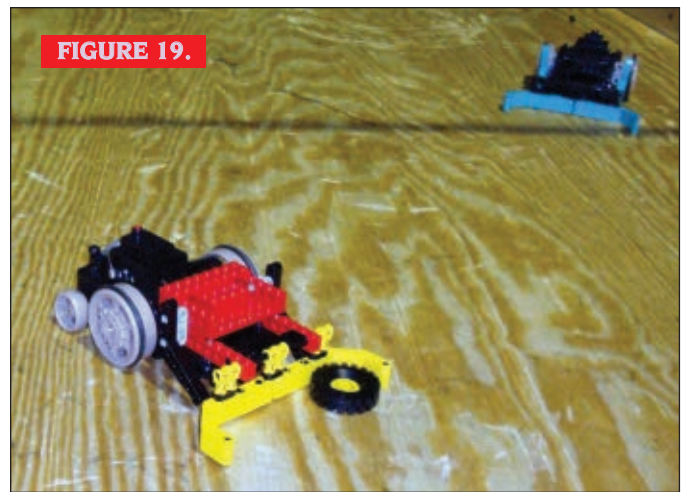


FIGURE 19.



FIGURE 20.



FIGURE 21.

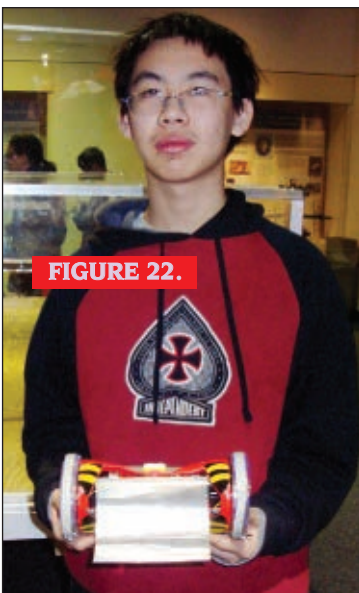


FIGURE 22.

Hack-A-Bot workshops in support of National Robotics Week. Hack-A-Bot is a program started by PennBots as a partnership with the Mount Holly Springs Library, in Mount Holly Springs, PA. Participants pay a nominal fee (usually around \$20) and in return receive an RC toy that can be hacked into a fighting robot.

PennBots provides the RC toys, construction materials, tools, and advice/help on how to hack the RC toys to meet



FIGURE 23.

the Ant weight limit, how to add armor/weapons, and driving strategy. Following several hours of construction, testing, and practice, Hack-A-Bot workshops culminate in a

double elimination tournament in a fighting robot arena. After several hours of hacking (Figure 9 shows PennBots' Dick Kelley melting hot glue with his soldering gun??), the morning workshop participants (Figure 10) completed a double elimination tournament and then competed in a robot rumble (Figure 11). Afternoon participants (Figure 12) continued the robotic construction and destruction with afternoon winner Pizza Flipper going vertical during an elimination match (Figure 13).

As an added incentive, Hack-A-Bot workshop participants were invited back to the National Electronics Museum the weekend of April 30th – May 1st to participate in a fighting robot competition as part of RobotFest.



FIGURE 24.



FIGURE 25.



FIGURE 26.



FIGURE 27.

RobotFest

PennBots returned to the National Electronics Museum on Saturday, April 30th, to provide fighting robot demonstrations as part of RobotFest. After rubbing elbows with B9 and R2D2 (**Figure 14**), checking out the fighting tanks (**Figure 15**) and Battleships (**Figure 16**), observing the 3D printers make chess pieces and robot parts (**Figure 17**), watching the Boy Scouts demonstrate their robots as part of earning their Robotics Merit Badge (**Figure 18**), and just taking in the great robotics atmosphere, the demonstration started with a game of Bot Hockey using PennBots club bots (**Figure 19**). Needless to say, it didn't take long for a fight to break out at the Bot Hockey game, and soon the PennBots club fighting robots, as well as some returning Hack-A-Bot fighting

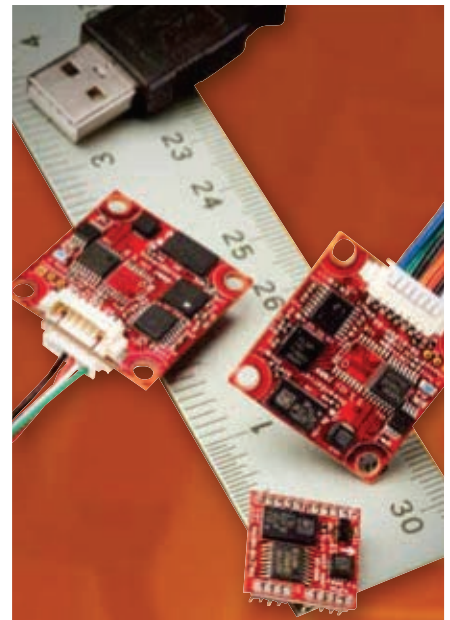
robots, joined the melee. RobotFest attendees took turns driving PennBots club fighting robots all afternoon (**Figure 20**). The main attraction on day two of RobotFest was the fighting robot competition. Participants in the competition (**Figure 21**) included three returning Hack-A-Bot workshop alumni, and one guest driver from a local high school who was attending the competition as part of an engineering study program. Fourteen Insect Class bots fought for the gold in Flea, Ant, and Beetle weight classes.

Guest driver Josh Gaus finished third in the Flea competition and won the Flea rumble. Hack-A-Bot participant Eric Hu and his fighting robot Crimson (**Figure 22**) took top honors in the Ant weight, while Dave Graham drove Snaggletooth (**Figure 23**) to victory in the Ant Rumble by depositing all challengers in the pit (**Figure 24**). Harry

Bates and his Beetle bot DisDroid (**Figure 25**) finished third, despite knocking the blade off of fan favorite and second place finisher The Mole (**Figure 26**), and giving winner Dick Kelley and Clamper a tough match (**Figure 27**). The complete list of winners is shown in **Table 2. SV**

	Flea	Ant	Beetle
1st Place	Dust Pan Dick Kelley	Crimson Eric Hu	Clamper Dick Kelley
2nd Place	Brutus Dave Graham	Snaggletooth Dave Graham	The Mole Dave Graham
3rd Place	Baby V Josh Gaus	Slicer Dick Kelley	DisDroid Harry Bates

Table 2. Robotfest Winners.



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Build This Beginner Bot (For Under \$20)

Part 1

We all have to start somewhere. For robotics, the first taste usually comes from putting together a basic starter kit. You build it, run it, learn a few core concepts, then put it on your shelf to use as a bookend. Most starter kits are single purpose, and don't grow with you.

Abetter approach is an expandable robot base that adapts while you learn. That's the idea of the BeginnerBot — specially designed for first-time robo builders. You start with basic robot construction, including motors and wiring, and you learn how robots move and steer. Using the same hardware (that saves you time and money), you then graduate to the next step, discovering electronic circuits and control. From there, you learn about microcontrollers, sensors, changing the behavior of your robot, and more.

The BeginnerBot is a low cost platform for exploring robotics. As its name implies, the BeginnerBot is ideal for beginners, and also students, teachers, and parents wanting to involve their kids in the world of robots. I designed it to be

by Gordon McComb

www.servomagazine.com/index.php?/magazine/article/august2011_McComb

both inexpensive — the basic mechanical parts cost about \$20 — and easy to make. You can construct the BeginnerBot in just a few hours, with nothing more than ordinary tools — things you already have in your garage. In this first installment, you'll learn how to build Phase 1 of the BeginnerBot, using your choice of wood or plastic (or getting the parts precut and predrilled, if that's your choice). You'll also learn about the art and science of controlling the motion of the robot — useful for things like chasing cats around the house.

You will then take this knowledge and use it to understand how autonomous robots are programmed to navigate their environment. In upcoming installments, you'll learn how to use the same BeginnerBot hardware with electronic control for feedback. From there, you'll discover how to add low cost microcontrollers for programmed response; then how to remotely control your bot; how to add inexpensive sensors to expand your robot's view of the world; and more.

Introducing the BeginnerBot

The BeginnerBot is shown in **Figure 1**. It measures six inches across, and like many robots of its type, uses a pair of motors and wheels for mobility. The two wheels are on opposite sides of the robot base. These wheels can be mounted center-line in the base, or offset to the front or back. For the BeginnerBot, the wheels are mounted center-line. That provides a bit more flexibility.

The size of the wheels greatly influences the travel speed of the robot. Larger wheels (for a given motor RPM) make the robot go faster. The wheels on the BeginnerBot measure about 2" in diameter. This means that for every revolution of the wheels, the robot travels approximately 6.3" ($2 \times \pi$, or 2×3.14). With the motors specified, the BeginnerBot moves at about one foot per second. A typical problem with constructing wheeled robots is connecting the wheels to the motors. The job is made easier when selecting wheels that



FIGURE 1. The BeginnerBot is an expandable, low cost base for exploring the world of desktop robotics.

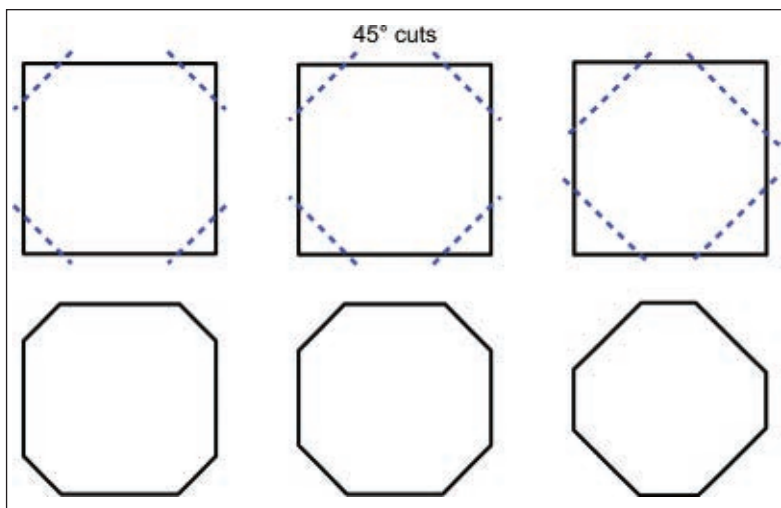


FIGURE 3. Cutting circular bases takes skill and patience. You can create “circle-ish” bases with just straight cuts by lopping off the corners of a square.

are engineered to fit specific types of motors or motor shafts. That’s the case with the BeginnerBot which uses commonly available Tamiya parts for both the wheels and the motors. The motors come as a kit; construction time is under 15 minutes per motor, and requires only a small screwdriver and pair of needle-nose pliers.

The arrangement of two drive wheels on each side of the robot is commonly termed *differential steering*. The name comes from how the robot is steered by changing the speed and direction (“difference”) between the two wheels, as shown in **Figure 2**. One of the key benefits of differential steering is that the robot can spin in place by reversing one wheel relative to the other.

A feature of most differentially steered robots is that they use one or two casters (or skids) placed in the front and/or back to provide support for the base. The first version of the BeginnerBot uses a simple static skid which is nothing more than the head of a metal machine screw. This works because the BeginnerBot isn’t very heavy, so there’s not much weight placed on the skid. The robot glides over the skid with its rounded shape providing only modest friction.

In a more enhanced version of the BeginnerBot that will be described in a later installment of this series, you’ll see how to flip over the robot’s base and attach a metal or plastic ball caster.

The Basics: Cutting Things to Size

You don’t need special tools or techniques to cut wood or plastic for a robot platform like the BeginnerBot. Basic shop cutting tools suffice: a handsaw, a backsaw, and/or a coping saw. When cutting plywood or soft plastics (like expanded PVC), use a wood handsaw or backsaw with medium teeth, or a motorized table saw. You’ll get the straightest cuts with the table saw. When cutting hard plastics (like acrylic), use a saw with fine teeth, or a motorized scroll saw. You can use a table saw if you outfit it with a blade suitable for cutting plastic. Make sure the blade is made for cutting the particular material. Wood blades have

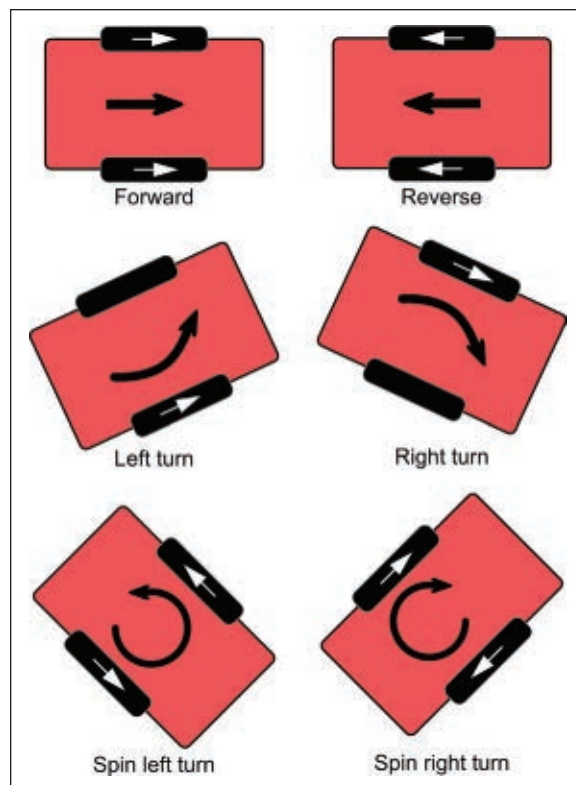


FIGURE 2. With differential steering, the rotation of the two wheels on either side of the base dictate the direction of the robot.

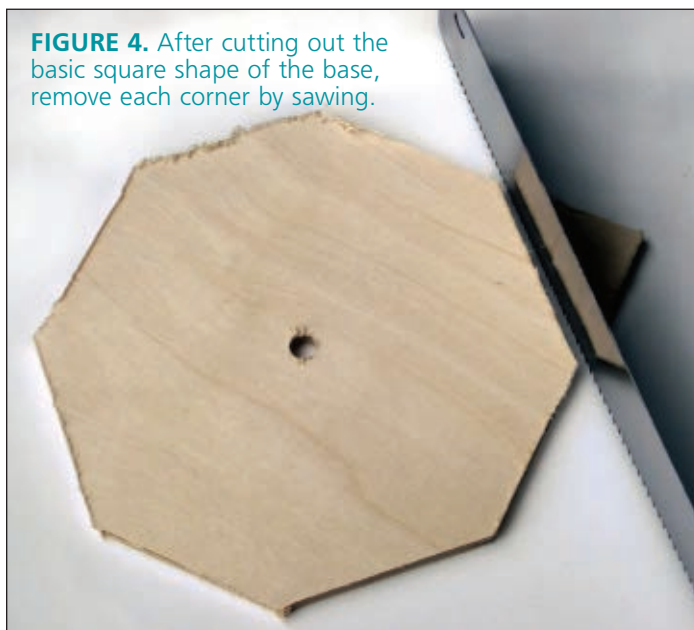


FIGURE 4. After cutting out the basic square shape of the base, remove each corner by sawing.

coarser teeth than blades for plastic. If using a power saw, use a plywood-paneling or crosscut blade. These have more teeth per inch and produce a smoother cut.

The easiest shape of all is square, and that’s what you’ll begin with, even if you plan on a more elaborate base. After all, what’s a circle than a square with lots and lots of corners! Start with a square or rectangle that’s the size of the finished robot base. If you have them, you can use power tools to make short work out of cutting the material. Problem is, square is not the ideal shape for a robot base because the

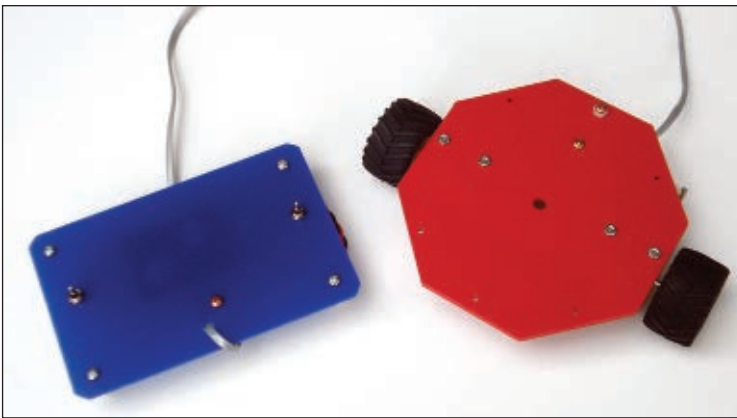


FIGURE 5. The finished Phase 1 BeginnerBot — both the base and the switch control panel.

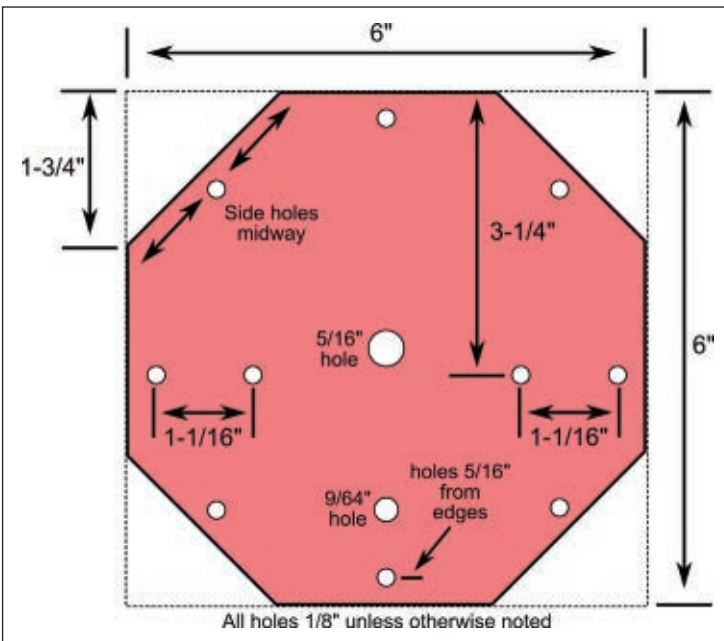


FIGURE 6. This is the cutting and drilling layout for the BeginnerBot base. Use 1/4" thick wood or plastic.

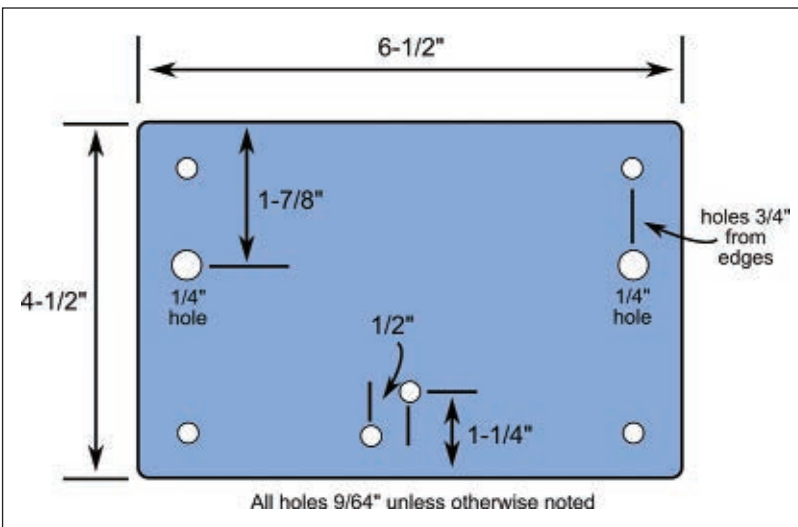


FIGURE 7. This is the cutting and drilling layout for the BeginnerBot control panel. Use 1/8" wood, plastic, or picture frame mat board.

corners can snag on things when the bot is driving around your living room. You can readily turn the square into an octagon, hexagon, or pentagon simply by lopping off the corners, like that in **Figure 3**. More elaborate shapes don't take that much longer to produce — just a few minutes per cut, and you'll make a better robot. To create an octagon (eight-sided) base, cut the corners off at 45° (see **Figure 4**). After cutting, use a medium or fine grit sandpaper to smooth the edges.

Cutting and Drilling the Base and Control Panel

The first version of the BeginnerBot is composed of two major pieces: the base of the robot and a control panel that you hold in your hands. In later variations of the BeginnerBot, this control panel will become a second expansion deck, mounted directly on the robot.

Both are shown in completed form in **Figure 5**. I call this Phase 1 of the BeginnerBot. Other phases (described in future articles in this series), use the same basic hardware parts, but in different configurations.

Figures 6 and 7 show the cutting and drilling guides for the base and control panel. Construct the base out of 1/4" thick material, either 1/4" aircraft-grade plywood or 1/4" (6 mm) expanded PVC plastic. You can buy the plywood at most any hobby or well stocked craft store; get the expanded PVC from a nearby sign-making shop or plastics distributor.

Cut the base from a 6" square piece of material. First, cut the base to its 6" square size, then remove the four corners as indicated. Don't worry about getting the cuts absolutely perfect. A fraction of an inch here or there won't matter. Construct the control panel from 1/8" plywood, acrylic plastic, or picture frame mat board. I used 1/8" acrylic plastic purchased from the nearby home improvement store. For a better look and feel, I used a small belt sander to round off the four corners. If you don't have a belt sander handy, place a sheet of sandpaper on the workbench, and vigorously rub the corners of the plastic against it. (If you don't feel like constructing the base or control panel, a kit of mechanical parts consisting of a precut and predrilled base and control board and all assembly hardware is available from Budget Robotics. See the **Sources** box.)

Use an electric drill or drill press to make the holes as shown. The sizes of drill bits to use are indicated in the illustrations. The exact location of the holes isn't super important, except for the four near the center line of the base. These are for mounting the two motors. Measure and drill these very carefully, as misplacement or misalignment of the holes can have a negative effect on the operation of your robot.

Use an electric drill or drill press to make the holes as shown. The sizes of drill bits to use are indicated in the illustrations. The exact location of the holes isn't super important, except for the four near the center line of the base. These are for mounting the two motors. Measure and drill these very carefully, as misplacement or misalignment of the holes can have a negative effect on the operation of your robot.

Assembling the Motors and Wheels

With the base and control panel prepared, lets

now turn to constructing the motors and wheels. You'll need the following:

- Two — Tamiya #70093 three-speed crank axle gearbox motor kits
- One pair — Tamiya #70096 off-road tires

These items are widely available through online retailers and some local hobby shops. See the **Sources** box for a selected list of Web retailers that carry these and other Tamiya parts. Assembly instructions are provided with the motor gearboxes and wheels. You will need a #0 Philips screwdriver and small needle-nose pliers. A pair of flush cutters — like the kind for snipping off the ends of wires when constructing circuit boards — is useful for separating the various plastic pieces.

The gearboxes can be constructed using one of three speed ratios: 17:1, 58:1, and 204:1. For Phase 1 of the BeginnerBot, select the 204:1 ratio. This is the slowest speed and the easiest to control. You can always disassemble the motor gearboxes and remake them at a faster speed (the 17:1 ratio is not useful for robot locomotion). Be sure to save all the extra parts in a reclosable plastic baggie so you can change out the gearing should you ever want to.

Each gearbox kit comes with a long hex-shaped drive shaft. You'll need to cut the shaft to length as shown in **Figure 8**. Do this before final assembly of the gearbox. After each gearbox has been built (but before you have inserted the small DC motor into the gearbox), loosen the set screw that holds the drive shaft in place. Adjust the position of the shaft within the gearbox as shown in **Figure 8**. You want about 1" of the shaft protruding from the outside of the gearbox. Retighten — but don't over tighten! — the set screw when the shaft is in the proper position.

(In order to access the set screw, you may need to manually rotate the gearing to make the screw accessible. Each motor comes with its own miniature hex wrench for tightening the set screw. Be sure to save the wrench for use later.) The wheels likewise come with their own assembly instructions. When mounting the rubber tires, orient the treads so the "V" pattern points to the same direction. Remember that the wheels are opposite one another, so the rubber tires need to be mounted on their wheel rims in mirror image.

Assembling the Base and Control Panel

With the motors and wheels made, you can now assemble the BeginnerBot base and control panel. Refer to **Figure 9** for where to mount the motors, skid, and cable clamp to the BeginnerBot base. The **Parts List** calls for mounting the motors using 4-40 x 7/16" pan or flat head screws. The head of the screws are on the side of the gearbox; the nuts are on the opposite side of the base.

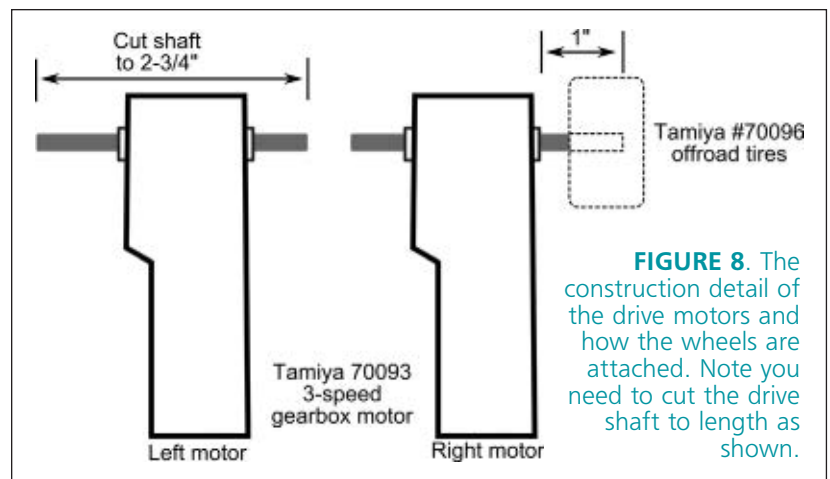


FIGURE 8. The construction detail of the drive motors and how the wheels are attached. Note you need to cut the drive shaft to length as shown.

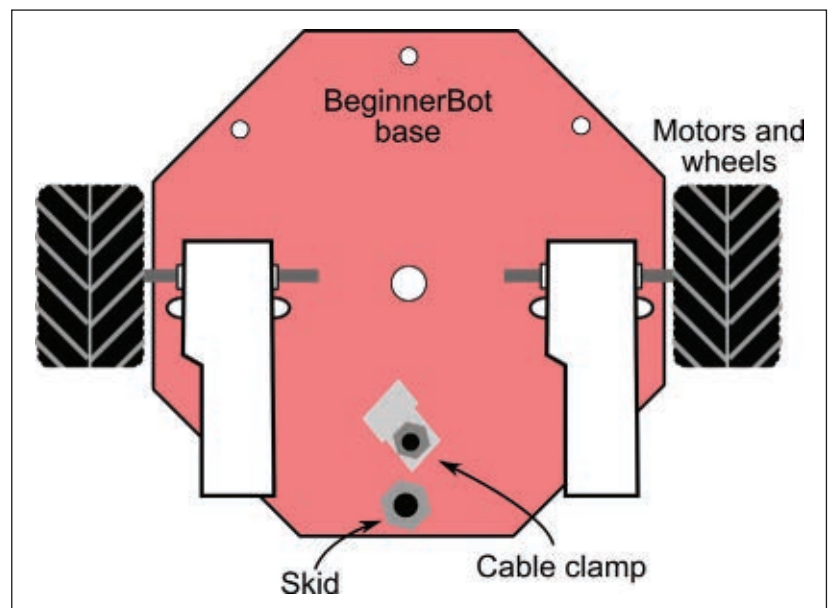


FIGURE 9. Notice where to mount the motors and other parts on the BeginnerBot base.

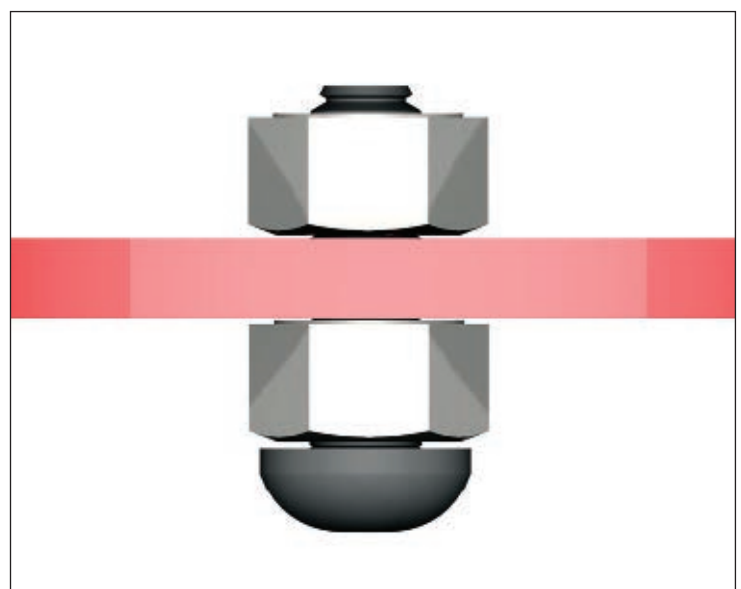


FIGURE 10. The balance skid is constructed using a pan head machine screw and two nuts. The head of the screw points down.

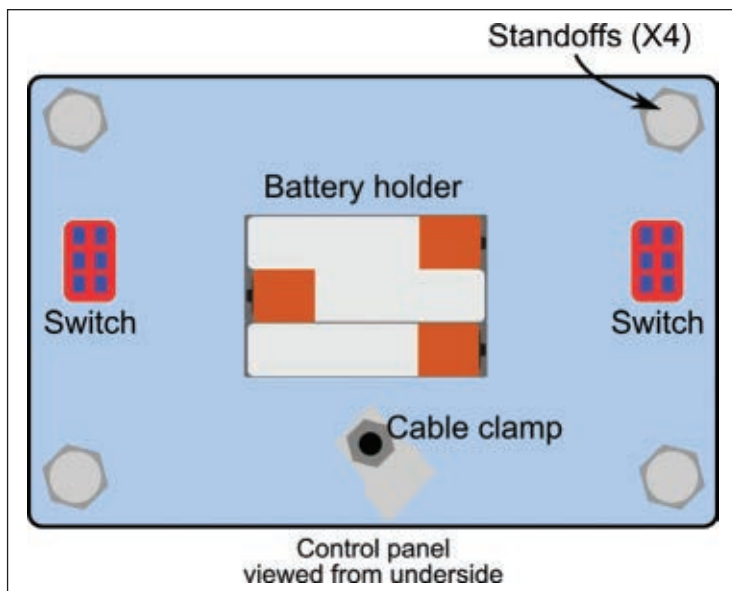


FIGURE 11. This shows where to mount the switches, battery holder, and other parts on the BeginnerBot control panel.

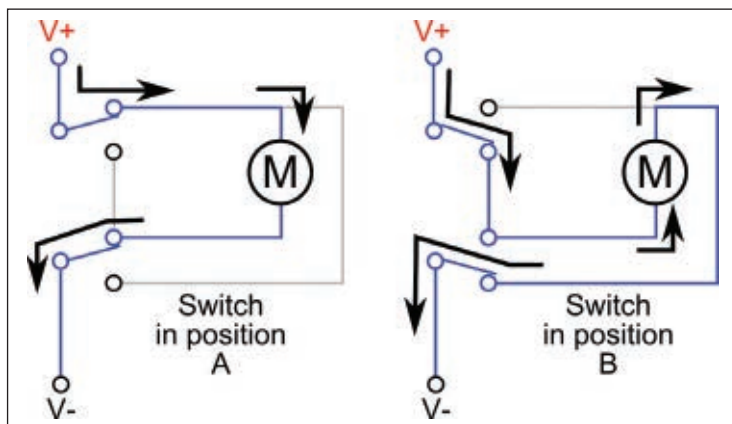
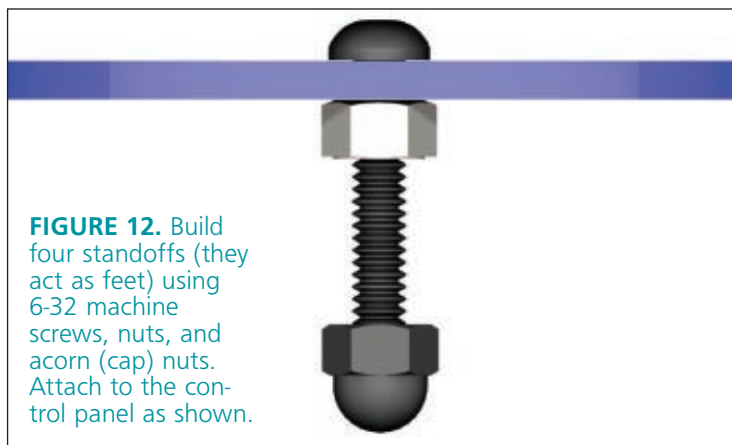


FIGURE 13. This shows how motor reversing is accomplished using a double-pole, double-throw switch.

Don't use longer screws, because they'll stick out too much and could drag against the floor. When using a skid, the motors are on the "top" of the base; remember, however, that the BeginnerBot is invertible — meaning it can be operated motor-side up or down. In future installments, I'll show a variation of the robot where the motors face down.

Figure 10 shows a side view of the base, indicating how

Sources

Precut and predrilled BeginnerBot base and control panel, with all construction hardware:

Budget Robotics
www.budgetrobotics.com

Tamiya motors, wheels:

Pololu
www.pololu.com

RobotShop
www.robotshop.com

Robot Marketplace
www.robotmarketplace.com

Solarbotics
www.solarbotics.com

Tower Hobbies
www.towerhobbies.com

Three-cell battery holder, hookup wire, double-pole, double-throw (DPDT) miniature momentary toggle switches (example: GC #35-018):

All Electronics
www.allelectronics.com

Digi-Key
www.digikey.com

Jameco Electronics
www.jameco.com

Marlin P. Jones
www.mpja.com

Parts Express
www.parts-express.com

RadioShack
www.radioshack.com

(Some of these are surplus sellers, so stock may come and go.)

to assemble the machine screw and two nuts to make the skid. Likewise, refer to **Figure 11** for how to mount the switches, corner standoffs, and cable clamp on the control panel. **Figure 12** shows the construction of the corner standoffs, which serve as "feet" for the control panel. The switches attach to the control panel using their own threaded nuts. Use one or two 1" squares of Velcro® to secure the battery holder to the underside of the panel.

Wiring the Motors and Control Panel

Phase 1 demonstrates the control of a robot using switch control. A set of two double-pole, double-throw (DPDT) switches operate the motors, and show how differential steering works. You can practice using the switches to see how different positions affect the motion of your robot.

For a full appreciation of how to control the BeginnerBot, choose miniature DPDT toggle switches that have a center-off position, as well as momentary "on" action. In electronics catalogs and online shopping carts, you'll often see these listed as: (on)-off-(on) or (mom)-off-(mom) where the (on) or (mom) in parenthesis means that the switch is spring-loaded. Releasing the toggle returns the switch to its off position.

Each switch controls one motor. In the center-off position, the motor is unpowered, so it doesn't move. The motor turns in one direction when the switch is pushed toward either on position. With the switch pushed toward the other position, the motor turns in the opposite direction.

Figure 13 shows the concept of how a DPDT switch is wired in order to reverse the direction of a motor. Note that in one position of the switch, current from the battery flows through the motor one way; when the switch is in the other position, current from the battery flows through the motor in

the opposite way. This is what causes the motor to reverse directions. Refer to **Figure 14** for how to wire the switches on the control panel to the motors on the BeginnerBot.

1. Start first by connecting the battery holder to the switches. Each switch needs power from the batteries. Be sure not to cross up the red (positive) and black (negative) connections between the switches, or you might create a short circuit.
2. Wire the switches as shown in blue. The criss-cross of the wires is what makes the motor reversal work.
3. Wire the switches to the motors using an eight or 10 foot length of four-conductor modular telephone extension. Clip off the modular plugs on either end, and strip back about five inches of the outer insulating jacket to expose the wires inside. The wires are color coded – red, black, green, and yellow (or orange) are common. Solder the switch and motor connections as shown.

(On the control panel end, thread the wire through the extra hole before soldering to the switches. This provides added strain relief.)

Note: Telephone wiring is made to be very flexible which is why it's chosen here. Many kinds have a thin filament that when soldered, burns away. It takes practice getting a good solder job with this stuff, so take your time and try again if your first attempt doesn't turn out. If you continue to have trouble, try a different brand of wiring, or substitute with four-strand ribbon cable. The ribbon cable isn't quite as flexible, but it will do for our purposes. Avoid the use of solid conductor wire. **Important!** The terminals on virtually all DPDT switches provide for the wiring diagram as shown in **Figure 14**. The switch has six terminals; two rows of three terminals each. The "common" connections of the switch are the two terminals in the middle.

If your switch came with a wiring diagram, check it to be sure the two center terminals are common. If you have a multimeter, dial it to test continuity, and apply one test lead to a common terminal and the other lead to a terminal on either side. Toggle the switch one way, then the other. In one of the positions, the meter should show continuity.

Keep the telephone wiring from pulling out by making a small coil around a 1/4" U-shaped plastic cable clamp. The clamp acts as a strain relief. Use a clamp on both the control panel and the robot base.

With the wires attached to the motors, fit the motors into their gearboxes. The solder terminals should be oriented so that they are not blocked by the body of the gearbox. The motors "click" into place. The design of the gearbox allows you to readily remove the motor – something we'll do in a later phase. The wiring of the finished BeginnerBot base and control panel is shown in **Figures 15** and **16**, respectively.

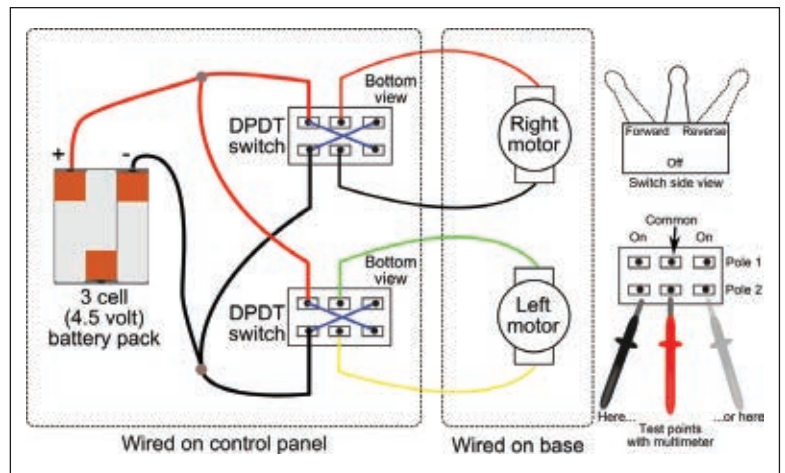


FIGURE 14. Wiring diagram for the BeginnerBot battery holder, switches, and motors. The connection between the switches and motors is through an eight to 10 foot length of four-conductor modular telephone wire.

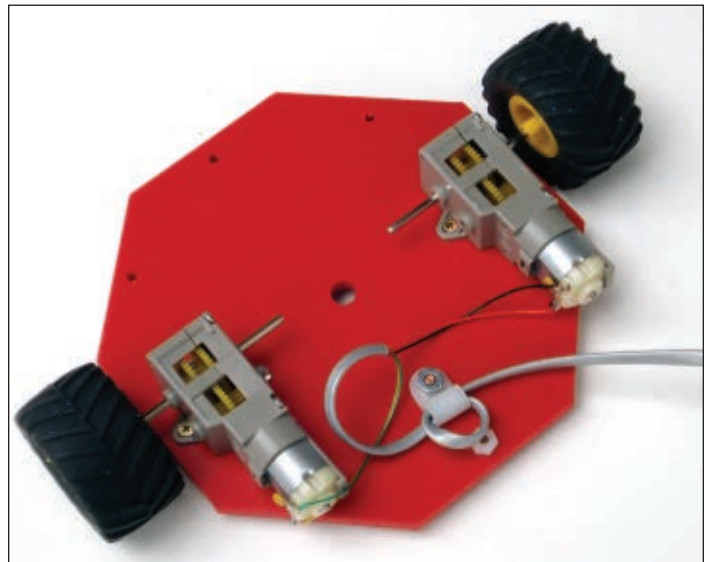


FIGURE 15. View of the BeginnerBot base showing all the wiring. This is actually the "top" of the robot for Phase 1.

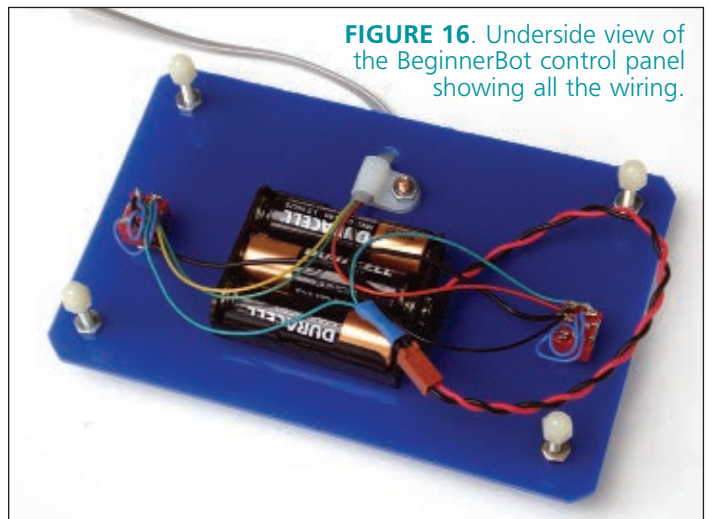


FIGURE 16. Underside view of the BeginnerBot control panel showing all the wiring.

Operating the BeginnerBot

Review your handiwork to check for accidental shorts,

bad soldering joints, or other problems. When you are satisfied all looks good, insert three AA batteries (standard

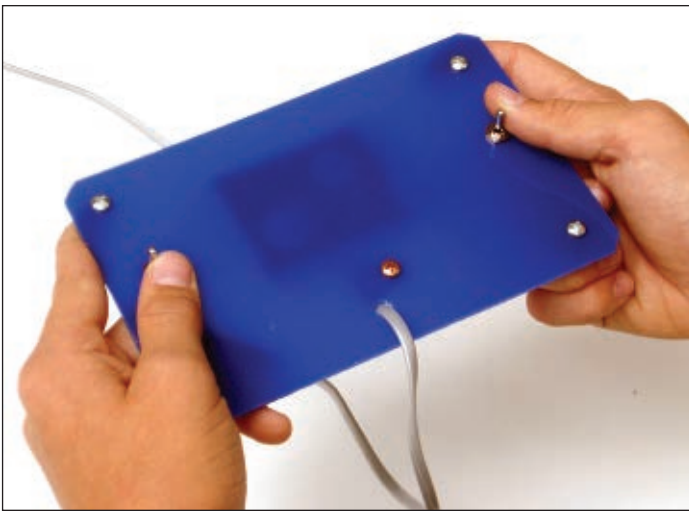


FIGURE 17. Control the motion of the BeginnerBot by flipping the position of the two switches. To make the robot stop, let go of the switches and have them spring back to their center off position.

alkaline or rechargeable) into the battery holder. Place the BeginnerBot base on a small book to lift its wheels from the ground, then try each of the control switches. The motors should turn as you flip the switches.

Test the operation of the BeginnerBot by putting it on the floor, motor-side up. With the control panel in your hands (see **Figure 17**), press both switches forward. The robot should move forward. ("Forward" and "backward" are arbitrary on the BeginnerBot, but for our purposes here, the back of the base is the end with the skid.)

MAKING ROUNDED BASES

You can approximate near circles by lopping off more corners from an octagonal base. Eight-sided octagons with their corners lopped off (chamfered) make 16-sided "cirlcettes" as shown in **Figure A**. To make these cuts, mark directly on the wood or plastic — you don't have to be precise — to the nearest 1/4".

Or, use a piece of graph paper lightly glued to the wood. You can use paper paste — the kind you ate in grade school — or a non-permanent glue stick.

If you have the proper tools, you can make circular bases using a circle cutting jig for a power router or jigsaw. The kind for jigsaws is fairly easy to use, and is the least expensive. It works just like a beam compass.

Start by drilling a hole in the approximate center of the wood, then adjust the circle-cutter to one-half the diameter of the circle you want. For instance, to make a 6" circle, you adjust the cutter to the 3" mark. You need to also make a starter hole for the jigsaw blade. Position the hole anywhere along the circumference of the circle.

Seat the anchor point of the cutting jig inside the center hole. Starting from the center hole you previously made, cut out the circle with the saw.

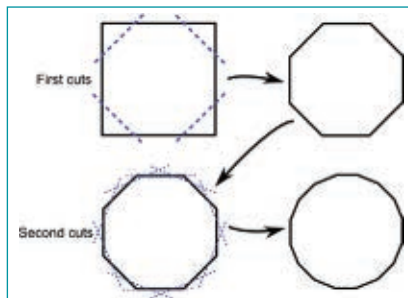


FIGURE A. Optional: Make even more rounded bases by lopping off the eight corners of an octagonal base.

If instead the robot moves backward, loosen the nuts on the switches and rotate both 180 degrees. Retighten the switch nuts. If the robot turns in a circle, loosen the nut on the switch controlling the motor that's going in the wrong direction. Rotate the switch 180 degrees, then retighten the nut. If the right and left switches control the wrong motor, flip the control panel around. Or, remove both switches, reverse their position on the panel, and put them back in.

Place the BeginnerBot in the center of the room. Practice steering the robot around the floor. You'll note that tight, spinning turns are performed by pulling back one switch while the other is pushed forward. A slower "pivoting" turn is accomplished by releasing one of the switches (depowering its motor) and letting the other motor continue. Have your BeginnerBot move toward a corner in the room, then see what kinds of motor control actions are needed to reverse its direction so it doesn't get trapped. The techniques you discover here are the same ones you'll use when the BeginnerBot is under automated electronic control (which will be covered later).

Next Phase: Electronic Control

So, now you've been introduced to the BeginnerBot. If you've followed along, you've constructed your bot, wired everything together, and tried it out in front of the family cat. You're now ready to move to Phase 2 which is converting the entry-level BeginnerBot from manual switch control to electronic control.

In the next part, you'll discover how to use rudimentary circuitry to give your BeginnerBot the sense of touch. It'll detect obstacles — even your friendly feline — and automatically steer around whatever doesn't get out of its way. **SV**

Parts List

QTY	ITEM
1	6" x 6" piece of 1/4" thick aircraft-grade plywood or 1/4" (6 mm) expanded PVC plastic
1	6-1/2" x 4-1/2" piece of 1/8" thick aircraft-grade plywood, acrylic plastic, or picture frame mat board
2	Tamiya #70093 three-speed crank axle gearbox motor kits
1 (pair)	Tamiya #70096 off-road tires
4	4-40 x 7/16" pan or flat head machine screws
4	4-40 nuts
3	6-32 x 1/2" pan head machine screws
4	6-32 x 1" pan head machine screws
8	6-32 nuts
4	6-32 acorn nuts
2	1/4" cable management clips
2	DPDT center off momentary bat handle miniature toggle switches (for 1/4" mounting hole, threaded bushing, with nut)
1	Three-cell (4.5 volt) AA battery holder
Misc.	24 or 26 gauge stranded hookup wire, eight or 10 foot length of four-conductor modular telephone extension wire

A kit of mechanical parts consisting of a precut and predrilled base and control board, and all assembly hardware is available from Budget Robotics, www.budgetrobotics.com. See the **Sources** box for a selected list of where to find other parts used in the BeginnerBot. Gordon may be reached at rbb@robotoid.

Meet the Swiss Army Knife of Robotics: the Cerebot 32MX7 ^{Part 2}

by Fred Eady

This month, we're going to tailor the Microchip TCP/IP stack to drive a PmodWiFi module via one of the SPI portals of our Cerebot 32MX7. While we're at it, we will also customize the USB Host portion of the Microchip Application Libraries and see if we can persuade the Cerebot 32MX7 to host a USB thumb drive.

Tailoring the Microchip Application Libraries involves editing the definitions within the library files to coincide with the target hardware. In the case of the PmodWiFi, we also have to make changes to some of the network definitions. We've got a fair amount of work to do. So, let's get started.

HardwareProfile PIC32_USB_SK_DM32003_2_MRF24WBOM.h

The Cerebot 32MX7's I/O pins and the TCP/IP stack hardware profile for the 32MX7 must match. Otherwise, we'll be spitting bits into the wind through the PIC32MX795F512L's output pins and sucking wind through the PIC's input pins. I suggest downloading an image of the 32MX7 and PmodWiFi schematics before we get down to business. That will make it a bit easier for you to follow the customization process. All of our input files exist in the Application Libraries. In the case of our Cerebot 32MX7 hardware profile include file, the seed file is *HardwareProfile PIC32_USB_SK_DM32003_2_MRF24WBOM.h* which is part of the TCP/IP demo application. Customization of the original files sometimes includes pruning. There's no sense in keeping the commented PIC18 and PIC24 code when we're compiling for the PIC32. Pruning also makes the modified code easier to read and debug. However, as with plants, too much pruning can be fatal. So, we'll only prune when absolutely necessary.

Let's reap the low hanging fruit. Buttons and LEDs are basic although necessary items to identify and assign to the 32MX7's I/O map:

```
// Hardware I/O pin mappings

// LEDs
#define LED0_TRIS    (TRISbits.TRISG12)    // Ref
LED1
#define LED0_IO      (LATGbits.LATG12)
#define LED1_TRIS    (TRISbits.TRISG13)    // Ref
LED2
#define LED1_IO      (LATGbits.LATG13)
#define LED2_TRIS    (TRISbits.TRISG14)
// Ref LED3
```

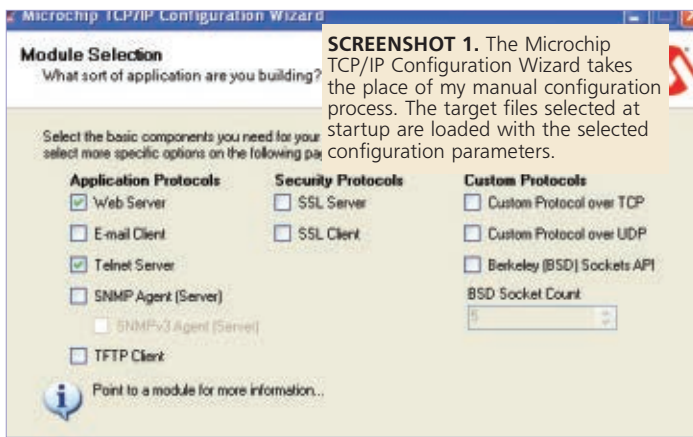
```
#define LED2_IO      (LATGbits.LATG14)
#define LED3_TRIS    (TRISbits.TRISG15)
// No such LED
#define LED3_IO      (LATGbits.LATG15)
#define LED4_TRIS    (TRISbits.TRISG15)
// No such LED
#define LED4_IO      (LATGbits.LATG15)
#define LED5_TRIS    (TRISbits.TRISG15)
// No such LED
#define LED5_IO      (LATGbits.LATG15)
#define LED6_TRIS    (TRISbits.TRISG15)
// No such LED
#define LED6_IO      (LATGbits.LATG15)
#define LED7_TRIS    (TRISbits.TRISG15)
// No such LED
#define LED7_IO      (LATGbits.LATG15)
#define LED_GET()    ((unsigned char)((LATG &
0xF000)>>12))
#define LED_PUT(a) do{LATG = (LATG & 0x0FFF) |
((a)&0x0F)<<12;}while(0)
```

Depending on the development board, some of the Application Libraries demo applications use up to eight LEDs. The Cerebot 32MX7 only uses four LEDs. Defining only four LEDs may lead to compiler headaches. It's a real pain to backtrack undefined LED errors. So, to avoid having to find and correct the undefined LED compiler errors, we'll code the unused LEDs as an extension to the last valid LED.

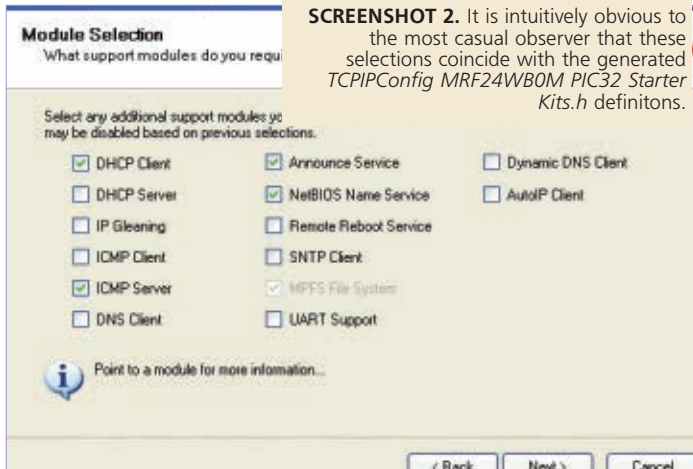
In that the 32MX7's LEDs are tacked physically to the most significant bits of LATG, we'll need to change the bit masking in the LED_GET and LED_PUT macros. As you can see, the LED_GET and LED_PUT macros act on the upper nibble of the most significant byte of LATG:

```
// Momentary pushbuttons
#define BUTTON0_TRIS (TRISbits.TRISG6)
// Ref SW1
#define BUTTON0_IO   (PORTGbits.RG6)
#define BUTTON1_TRIS (TRISbits.TRISG7)
// Ref SW2
#define BUTTON1_IO   (PORTGbits.RG7)
#define BUTTON2_TRIS (TRISbits.TRISD13)
// Ref SW3
#define BUTTON2_IO   (PORTDbits.RD13)
#define BUTTON3_TRIS (TRISbits.TRISD13)
// No BUTTON3 on this board
#define BUTTON3_IO   (PORTDbits.RD13)
```

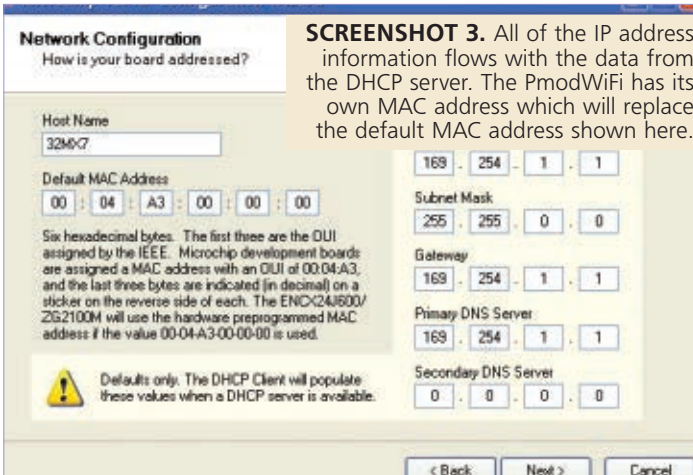
The same logic that applies to the 32MX7's LEDs applies



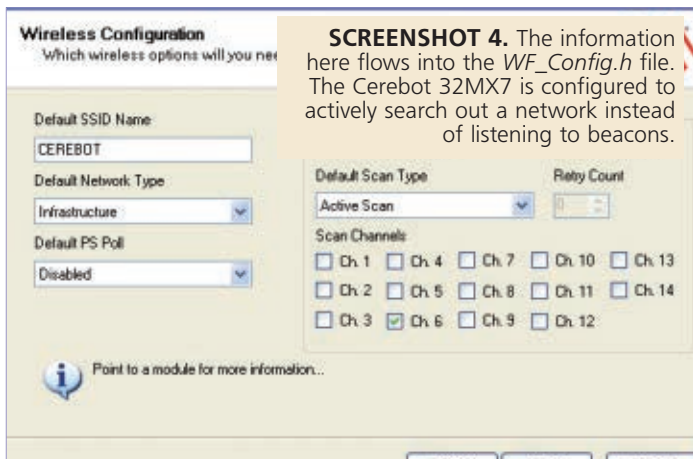
SCREENSHOT 1. The Microchip TCP/IP Configuration Wizard takes the place of my manual configuration process. The target files selected at startup are loaded with the selected configuration parameters.



SCREENSHOT 2. It is intuitively obvious to the most casual observer that these selections coincide with the generated TCPIPConfig MRF24WB0M PIC32 Starter Kits.h definitions.



SCREENSHOT 3. All of the IP address information flows with the data from the DHCP server. The PmodWiFi has its own MAC address which will replace the default MAC address shown here.



SCREENSHOT 4. The information here flows into the WF_Config.h file. The Cerebot 32MX7 is configured to actively search out a network instead of listening to beacons.

to its pushbuttons. Only pushbuttons 0, 1, and 2 are physically available. Since USB is readily available, there are no plans to use a UART. However, we must modify the UART TRIS bits to avoid a conflict with the SPI portal:

```
#define UARTTX_TRIS    (TRISFbits.TRISF13)
#define UARTRX_TRIS    (TRISFbits.TRISF22)
```

The MRF24J40MB communicates with the 32MX7's PIC32MX795F512L over an SPI channel. If you take a look at the 32MX7 and the PmodWiFi schematics, port JD seems to be the closest fit for the MRF24J40MB-based PmodWiFi module. However, port JE is the best fit for the 32MX7. So, we'll alter the SPI2 definitions to point to port JE of the Cerebot 32MX7:

```
// _____
// MRF24WB0M WiFi I/O pins
// _____
// MRF24WB0M in CEREBOT 32MX7 PORT JE
// MRF24WB0M in SPI2 slot
#define WF_CS_TRIS      (TRISDbits.TRISD14)
#define WF_CS_IO        (LATDbits.LATD14)
#define WF_SDI_TRIS     (TRISFbits.TRISF2)
#define WF_SCK_TRIS     (TRISDbits.TRISD15)
#define WF_SDO_TRIS     (TRISFbits.TRISF8)
#define WF_RESET_TRIS   (TRISAbits.TRISA6)
#define WF_RESET_IO     (LATAbits.LATA6)
#define WF_INT_TRIS     (TRISAbits.TRISA14)
// INT3
#define WF_INT_IO        (PORTAbits.RA14)
#define WF_HIBERNATE_TRIS (TRISAbits.TRISA7)
#define WF_HIBERNATE_IO (PORTAbits.RA7)
#define WF_INT_EDGE     (INTCONbits.INT3EP)
#define WF_INT_IE        (IEC0bits.INT3IE)
#define WF_INT_IF        (IFS0bits.INT3IF)
#define WF_INT_IE_CLEAR IEC0CLR
#define WF_INT_IF_CLEAR IFS0CLR
#define WF_INT_IE_SET    IEC0SET
#define WF_INT_IF_SET    IFS0SET
#define WF_INT_BIT       0x00008000
#define WF_INT_IPCSET    IPC3SET
#define WF_INT_IPCCLR    IPC3CLR
#define WF_INT_IPC_MASK  0xFF000000
#define WF_INT_IPC_VALUE 0x0C000000

#define WF_SSPBUF        (SPI3BUF)
#define WF_SPISTAT        (SPI3STAT)
#define WF_SPISTATbits    (SPI3STATbits)
#define WF_SPICON1        (SPI3CON)
#define WF_SPICON1bits    (SPI3CONbits)
#define WF_SPI_IE_CLEAR   IEC0CLR
#define WF_SPI_IF_CLEAR   IFS0CLR
#define WF_SPI_INT_BITS   0x1C000000
#define WF_SPI_BRG        (SPI3BRG)
#define WF_MAX_SPI_FREQ   (10000000ul) // Hz
```

Navigating the Interrupts chapter of the *PIC32 Family Reference* is akin to reading *War and Peace*. As far as interrupts are concerned, in a nutshell what we've done in our customization is set up a basis for recognizing, setting, and clearing the interrupt bits associated with the SPI3 portal and external interrupt INT3.

TCP/IP Configuration

I normally perform the TCP/IP configuration by manually altering the contents of the TCP/IP stack's configuration files. It's time to change my old-fashioned ways. This time around, we'll configure TCP/IP using the Microchip TCP/IP Configuration Wizard. The target files are *TCPIPConfig MRF24WB0M PIC32 Starter Kits.h* and *WF_Config.h*.

Let's walk through the TCP/IP configuration process. If a screenshot contains items we don't care about, I'll forego displaying it here. The initial screen allows us to enter the target files. **Screenshot 1** follows the target entry screen and is a capture of my application protocol selections. I have this thing about Telnet. I've chosen to bypass the example modules and performance tests offered in the next window. Normally, I would manually comment out the undesirable features. However, in the click-it environment of the TCP/IP Configuration Wizard, all I have to do is select them as I did in **Screenshot 2**. The generated definitions that follow are taken from the file *TCPIPConfig MRF24WB0M PIC32 Starter Kits.h*:

```
#define STACK_USE_ICMP_SERVER
// Ping query and response capability
#define STACK_USE_HTTP2_SERVER
// New HTTP server with POST, Cookies,
// Authentication, etc.
#define STACK_USE_DHCP_CLIENT
// Dynamic Host Configuration Protocol
// client for obtaining IP address and
// other parameters
#define STACK_USE_TELNET_SERVER
// Telnet server
#define STACK_USE_ANNOUNCE
// Microchip Embedded Ethernet Device
// Discoverer server/client
#define STACK_USE_NBNS
// NetBIOS Name Service Server for
// responding to NBNS hostname broadcast
// queries
```

The inclusion of `STACK_USE_DHCP_CLIENT` allows us to pretty much leave everything as is in **Screenshot 3**. However, we do have the opportunity to choose our Cerebot 32MX7's host name which ends up as an entry in the *TCPIPConfig MRF24WB0M PIC32 Starter Kits.h* file:

```
#define MY_DEFAULT_HOST_NAME "32MX7"
```

I have configured my wireless router to operate on Channel 6. While I was in the configuring mood, I also selected an SSID for our future 32MX7/PmodWiFi network. In **Screenshot 4**, I entered the same SSID that I loaded into the router. This time, the configuration data I entered found its way into the *WF_Config.h* file:

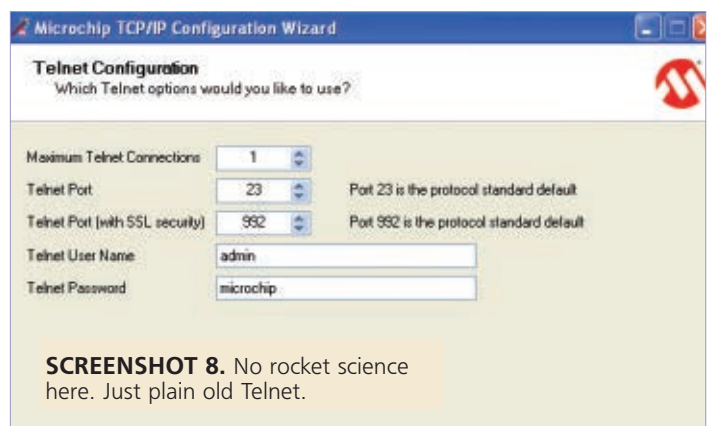
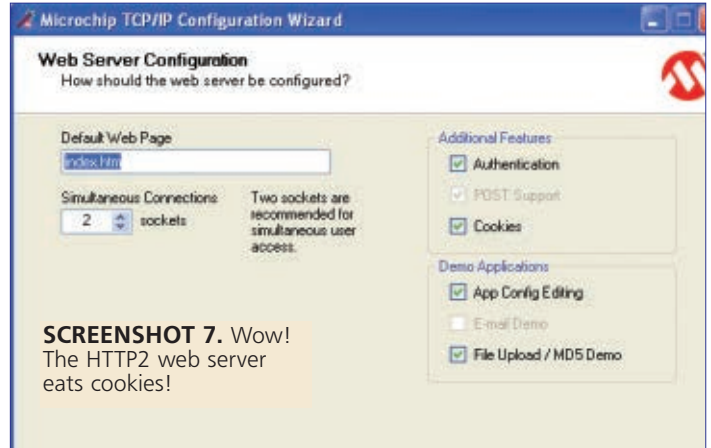
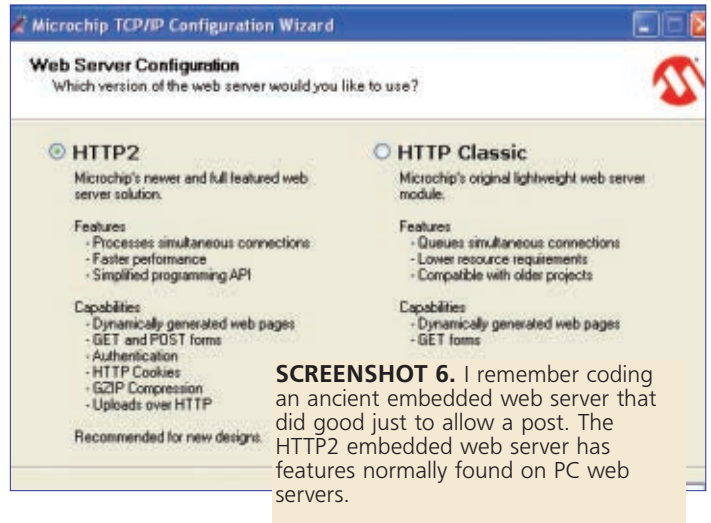
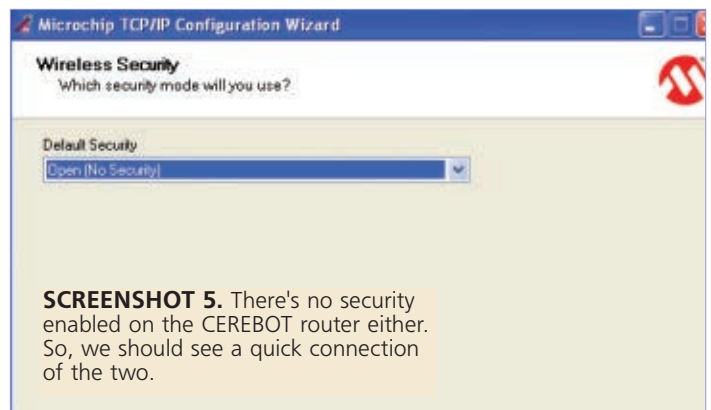
```
//Default settings for Connection Management
#define MY_DEFAULT_SSID_NAME "CEREBOT"

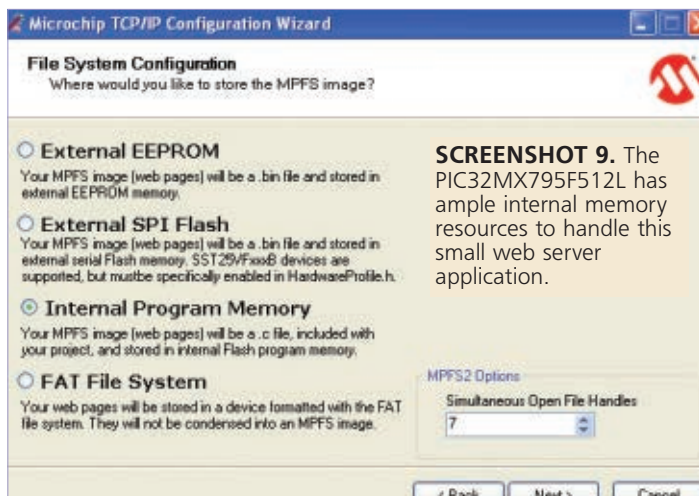
#define MY_DEFAULT_NETWORK_TYPE WF_INFRA
STRUCTURE
#define MY_DEFAULT_SCAN_TYPE WF_ACTIVE_
#define MY_DEFAULT_CHANNEL_LIST {6}
#define MY_DEFAULT_LIST_
ENTRY_COUNT (WF_RETRY_FOREVER)

#define MY_DEFAULT_EVENT_NOTIFICATION_LIST
(WF_NOTIFY_CONNECTION_ATTEMPT_SUCCESSFUL | \
WF_NOTIFY_CONNECTION_ATTEMPT_FAILED | \
WF_NOTIFY_CONNECTION_TEMPORARILY_LOST | \
WF_NOTIFY_CONNECTION_PERMANENTLY_LOST | \
WF_NOTIFY_CONNECTION_REESTABLISHED)

#define MY_DEFAULT_PS_POLL WF_DISABLED
#define MY_DEFAULT_WIFI_SECURITY
_MODE WF_SECURITY_OPEN
```

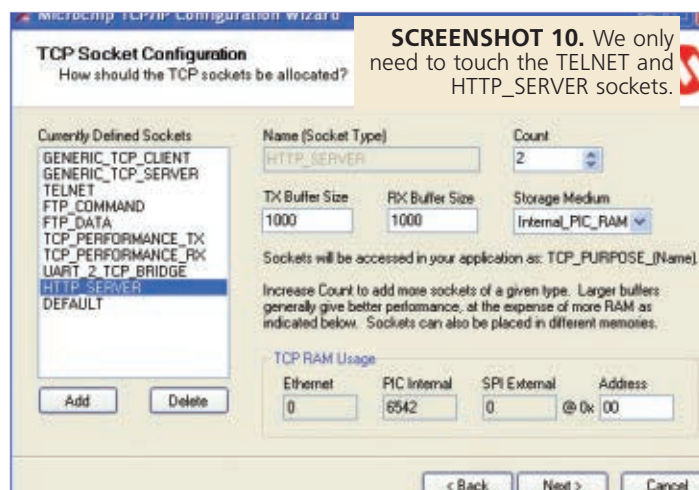
As you can see, a lot of other configuration elements shown in **Screenshot 4** made it into the *WF_Config.h* file, as well. If security is enabled, the keys would also be placed into the *WF_Config.h* file. I figure we should concentrate on establishing a connection before we worry about security. So,





PmodWiFi Signal	PmodWiFi Pin	JE Port Signal	JE Port Pin	J8 Header Pin
/CS	1	SS1A	1	
SDI	2	SDO1A	2	
SDO	3	SDI1A	3	
SCK	4	SCK1A	4	
GND	5	GND	5	
VCC	6	VCC	6	
/INT	7			SCL1
/RESET	8	RA6	7	
/WP	NC	NC	NC	
HIBERNATE	10	RA7	8	
GND	11	GND	11	
VCC	12	VCC	12	

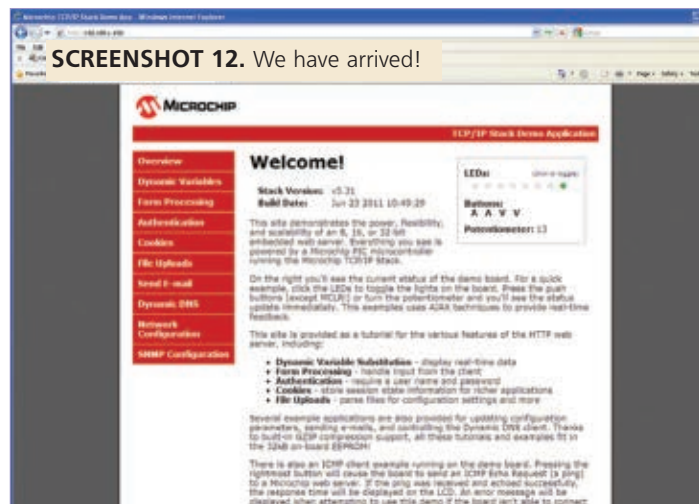
Table 1.



IP Address	Host Name	MAC Address
192.168.1.100		00-1E-C0-02-75-5C
192.168.1.103	sniper	00-1A-6B-36-7C-4D

SCREENSHOT 11. This is a welcomed site. Sniper is my laptop. The unnamed host is the Cerebot 32MX7.

[Refresh](#)



component of the TCP/IP stack. Everything that has to do with how the HTTP2 web server responds can be found within the confines of the *TCPIPConfig MRF24WB0M PIC32 Starter Kits.h* file. **Screenshot 7** defines the default web page and adds features that used to be found on PC-class web servers. I like to use Telnet as one of the contact methods for embedded hosts like the Cerebot 32MX7. We'll keep it simple and leave the Telnet options to default in **Screenshot 8**.

The MPFS2 file system provides the necessary storage support for the HTTP2 web server. We'll store our web pages in MPFS2-formatted .c files in the PIC32MX795F512L's program Flash. To do this only requires that we choose Internal Program Memory in the File System Configuration window captured in **Screenshot 9**. Buffer memory allocation for the HTTP2 web server and Telnet server is handled in **Screenshot 10**. Before we compile and load our TCP/IP stack firmware, we still have a little hardware work to take care of. The hardware work isn't heavy and is centered on the 32MX7's JE plug.

Physical Hardware Configuration

Fred Eady's First Rule of Embedded Computing states that nothing is free. We're going to steal the INT3 signal line from the Cerebot 32MX7's on-board I²C EEPROM IC. This will render the EEPROM useless; we weren't using it in this application anyway. The theft of the INT3 signal does not require any permanent hardware changes. All of the wire twiddling will take place on the 32MX7 side of a 12-conductor cable that we will place between the 32MX7 and the PmodWiFi module. The INT3 signal line is called P32_SCL1 in the Cerebot 32MX7 schematic. We will physically separate the INT3 line by removing it from the JE side of the plug-in connector. The isolated INT3 pin will be connected to the SCL1 header pin on the 32MX7 (PCB).

On the 32MX7 side, I/O pin RA6 is attached to pin 7 of portal JE. Pin 7 of port JE is the INT pin on the PmodWiFi side of the connection. We just yanked the wire out of pin 7 to satisfy the INT3 connection. We still need RA6 as it is assigned to the PmodWiFi's RESET signal. To reestablish this connection, we'll simply move the connector pin at JE pin 8 to JE pin 7. JE pin 8 — which is assigned to the PmodWiFi HIBERNATE signal — is now open at the plug-in connector. The HIBERNATE signal is located on pin 10 of the PmodWiFi.

I've made my point in **Screenshot 5**.

In the STACK_USE selections by way of **Screenshot 6**, we indicated that we want to use the HTTP2 web server

So, we only need to move pin 10 of the JE plug-in connector to the vacant JE pin 8 position.

The physical hardware reconfiguration is complete. A table is worth 1000 electrons (see **Table 1**). The cable surgery is under the lights in **Photo 1**. The pinout of the Cerebot 32MX7's I/O ports doesn't follow the industry standard of even pin numbers on one column of pins and odd numbered pins on the opposing column. Instead, count from pin 1 down to pin 6. Pin 7 opposes pin 1 and count from pin 7 down to pin 12. The power pins are an easy way to identify the pin numbers as opposing pins 5 and 11 are GND and opposing pins 6 and 12 are VCC.

Compile and Run

In that **Photo 1** exists, the Cerebot 32MX7/PmodWiFi combination passed the magic smoke test. So, let's compile our TCP/IP stack code and load it using the 32MX7's Area 51 electronics. I loaded the TCP/IP stack code in debug mode just in case. After turning the code loose, the 32MX7's LED1 began to flash. That's a good sign. I then fired up the router's management screen and took a look at its DHCP client list. Check out **Screenshot 11**. The MAC address of the host at 192.168.1.100 matches the MAC address of the PmodWiFi module under the lens in **Photo 1**.

Since I'm on a roll, let's see if the HTTP2 server is working. Opening Internet Explorer and entering <http://192.168.1.100> resulted in **Screenshot 12**. All of the interactive buttons and LEDs worked to boot. A Telnet open request to the same IP address proved that our Telnet server application was active as well. Yep. Ping worked too.

A Touch of USB

Now that we have the PmodWiFi module bending the magnetic field, let's ease into a bit of USB. I've already started the merger by modifying our existing PIC32MX795F512L Wi-Fi configuration fuse suite:

```
#pragma config UPLLEN =      ON
// USB PLL Enabled
#pragma config FPLLMUL      = MUL_20
// PLL Multiplier
#pragma config UPLLDIV      = DIV_2
// USB PLL Input Divider
#pragma config FPLLDIV      = DIV_2
// PLL Input Divider
#pragma config FPLLODIV      = DIV_1
// PLL Output Divider
#pragma config FPBDIV        = DIV_1
// Peripheral Clock divisor
#pragma config FWDTEN        = OFF
// Watchdog Timer
#pragma config WDTPS         = PS1
// Watchdog Timer Postscale
#pragma config OSCIOFNC      = OFF
// CLKO Enable
#pragma config POSCMOD       = HS
// Primary Oscillator
#pragma config IESO          = OFF
// Internal/External Switch-over
#pragma config FSOSCEN       = OFF
// Secondary Oscillator Enable
#pragma config FNOOSC        = PRIPLL
// Oscillator Selection
```

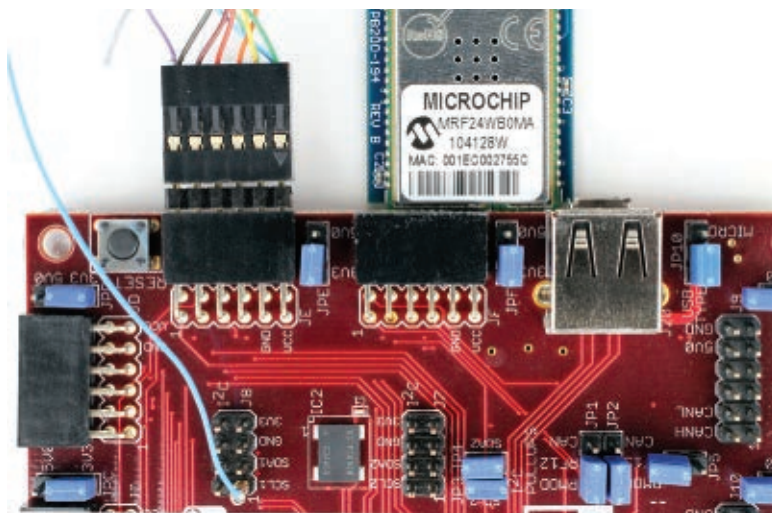


PHOTO 1. Be careful. Don't get up on your donkey and declare that pin 2 is across from pin 1. The Cerebot 32MX7's ports number 1 through 6 on one side and 7 through 12 on the opposite side. The trick to remembering this is that opposing pins 5 and 11 are GND and opposing pins 6 and 12 are VCC.

```
#pragma config CP            = OFF
// Code Protect
#pragma config BWP           = OFF
// Boot Flash Write Protect
#pragma config PWP           = OFF
// Program Flash Write Protect
#pragma config ICESEL         = ICS_PGx2
// ICE/ICD Comm Channel Select
#pragma config DEBUG          = ON
// Background Debugger Enable
```

Note the addition of USB PLL configuration fuses. I've already recompiled with the new USB configuration fuses and everything works as before. The next step involves adding the USB stack components to our PmodWiFi project. Once the USB stack stuff is installed and verified, the mass storage drivers can be integrated.

The Cerebot 32MX7 is fully capable of being a USB host while servicing the needs of the PmodWiFi module. A hefty 5.0 volt at four amperes wall wart came with my 32MX7. It will come in handy as the 32MX7 must be powered externally when acting as a USB host. Unlike a USB client, a USB host must provide 5.0 volts at 500 mA at its USB portals.

Next Time

We'll finish the USB integration. I'll post all of the PmodWiFi source code and the raw USB integration statements I've melded in thus far in the download package. Meanwhile, I'll get back to work at Area 51. **SV**

[www.servomagazine.com/index.php?
/magazine/article/august2011_Eady](http://www.servomagazine.com/index.php?/magazine/article/august2011_Eady)

Fred Eady can be reached via email at fred@edtp.com.

Sources

Digilent
Cerebot 32MX7
PmodWiFi Module
www.digilentinc.com

Microchip
Microchip Application
Libraries
PIC32MX795F512L
www.microchip.com

YT4 Human Robot

by Anthony Cherone

[www.servomagazine.com/index.php?
/magazine/article/august2011_Chерone](http://www.servomagazine.com/index.php?/magazine/article/august2011_Chерone)

Picture sitting in your home, driving a human-like robot and interacting with others in real time all from your laptop. This robot can interact, communicate, and utilize functional hands, arms, and elbows. Now, envision all the cool, cutting edge applications and know that nothing is impossible!

Physical Construction

Base Structure

The idea behind YT4 was to create a design that would look good and serve the purpose of adding stability and a multi-level structure strong enough to house the components being used. Building off a tank tread kit from Lynxmotion, a customized base was created making deck layers out of .220" thick clear lexan panels custom-cut to size and designed using a dremel. Aluminum U brackets and T6 0.50" six inch round aluminum tubing with hubs were fabricated and mounted to the panels to form the support system under the multi-layer architecture as shown in **Figure 1**. This was done by taking measurements and drilling the mounting holes attaching the support tubes and brackets to the lexan panels using hex screws to fasten things in place. It was imperative to plan everything out first and drill holes as necessary to mount switches, brackets, or any other components used.



Torso

Creating the torso for YT4 added height, stability, and body-like features. Working from the upper deck panel on the base, I drilled eight 2-56 holes at pre-marked spots mounting two 1/4" aluminum spacers to anchor down the torso. Next, hubs were attached to the spacers along with six inch aluminum tubing which created a ladder design, making it taller yet stable, as well.

Repeating that step one more time going higher, the top was bracketed together using a single custom-cut piece of tubing to add some extra height. At the top of the tallest tube, a hub was used to connect the tube to the upper body of YT4.

Upper Body

The head and arms were added to the construction of YT4 to give it a more authentic human-like appearance. Using brackets from a servo erector set and 12 Hitec 645MG servos with 133 oz torque, the arms began to replicate the characteristics of modern human beings.

All the servos were set up with a Propeller servo controller driven by a BASIC Stamp 2 microcontroller. The servo positions are set to limit different ranges, mimicking the typical human range of motion. A seven inch LCD monitor with built-in speakers sits on top of YT4's shoulders, along with a Logitech web cam mounted to aluminum brackets which rests on a high torque servo.

The servo allows rotation of the head from side to side to view all surroundings. The LCD screen is powered by the main 12 volt battery source, while the web cam is connected to a MAC Mini via USB. A video cable is wired from the screen and connected to a DVI-to-RCA adapter attached to the MAC. Sound cables are then run from the head down to the speaker jack on the MAC Mini, thus providing audio and video (refer to **Figure 2**).

Intelligence

In an attempt to replicate human senses, onboard notification of the environment was created by using the power of a Mac Mini G4 and five BS2 and BS2PX single-board computers from Parallax that run a PBASIC language interpreter, bringing YT4 to life. Each microcontroller has its own custom program and task including remote motor control, temperature measurement, tilt balance, and object detection as seen in **Figure 3**.

One of the microcontrollers (using an infrared temperature sensor with a 90 degree field of view) is used for measuring environmental temperatures. Developing a code in PBASIC allows the sensor to measure the temperature repeatedly. Once it approaches either the hot or cold threshold that is set, an alarm sounds and displays hot or cold color assortments on the front chest of the robot. Measuring temperature allows the user to become aware of extreme

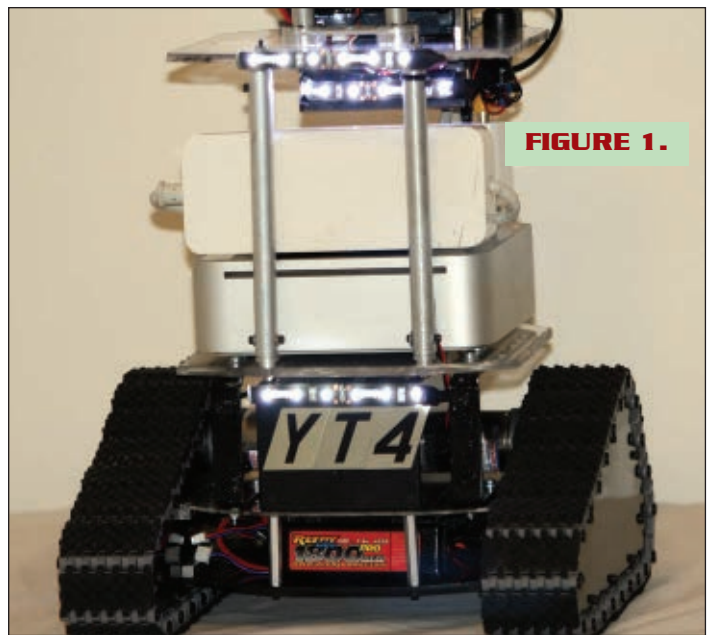


FIGURE 1.

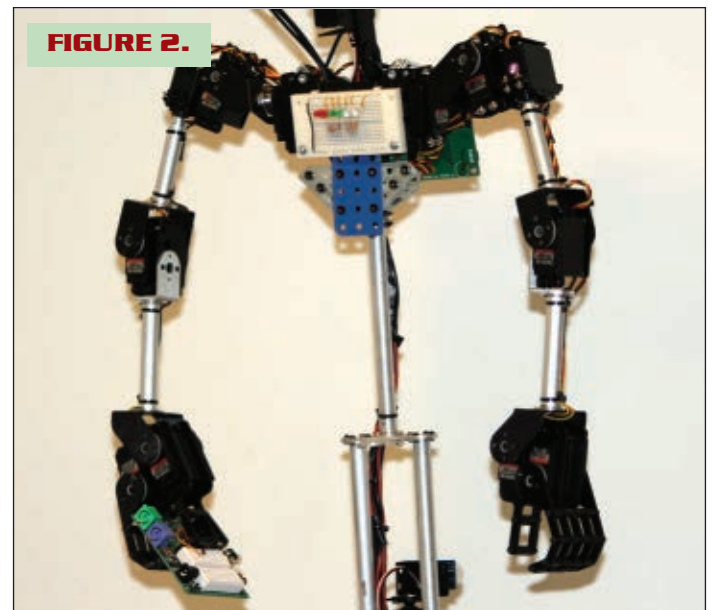


FIGURE 2.

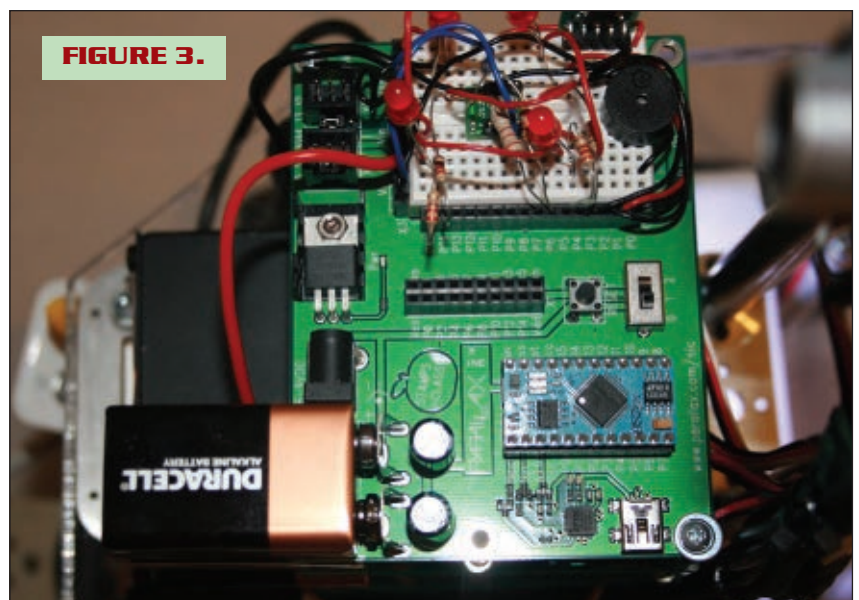
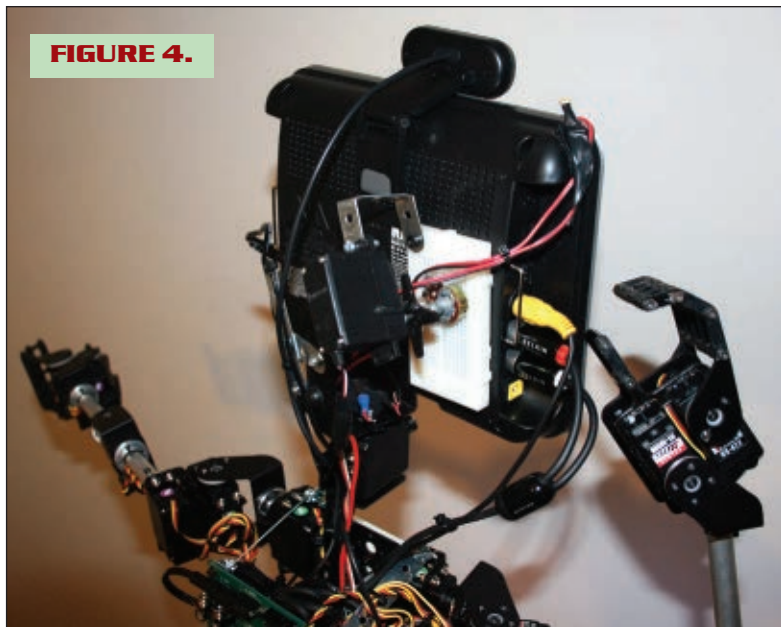


FIGURE 3.

FIGURE 4.



constants, it will be able to determine if something interrupts its path by calculating new distance measurements then comparing them to the old distance measurements. Once movement is detected within a 60 cm range, an alarm tone is activated warning the operator someone or something is behind YT4.

Another nifty feature is the automatic headlights which were created using a potentiometer, servo, and photoresistor that are mounted on the head (**Figure 4**). Developing a code with the Stamp editor while using a photoresistor to measure the light percentage continuously allows YT4 to determine whether or not to dim the LED lights on or off automatically. When the environment darkness approaches a certain light percentage embedded in the program, it sends a pulse to the servo mounted on the potentiometer to rotate at a specific speed and time either decreasing or increasing resistance while increasing or decreasing the supply voltage to slowly dim the lights off or turn them on.

Vision System

Being able to navigate the environment by sight is critical and require utilization of a Logitech USB web cam connected to the Mac. Operating YT4 remotely requires real time vision to view surroundings and to communicate with others. Using the live web cam feed or a video chat application, live video can be viewed from the web cam on YT4 to a remote laptop. Using a video chat application within the remote desktop program, the user is able to video chat using two different application accounts.

Video chatting between the Mac and a PC allows the user to view themselves from the web cam on their laptop while viewing video from the Mac web cam within the same shared screen. Being able to view yourself (as shown in **Figure 5**) allows the user to project their image to YT4's LCD screen while viewing Mini's web cam in a split screen. While the user's image is projected to the robot's screen, people see their face in real time on the robot as it is interacting, and at the same time the user can have full vision of the environment during operation of YT4.

FIGURE 5.



Remote Operation System

The track system used has upgraded 12 VDC gear head motors with a 50:1 reduction which produces 152 RPM. Driving the motors are two HB-25 motor controllers daisy-chained to a Stamp 2 microcontroller as shown in **Figure 6**. Removing the jumper from the second motor controller, installing a three-pin jumper extension cable from one motor controller to the other, then installing another three-pin cable extension from the first motor controller to pin 15 on the

PARTS LIST

- Seven inch LCD screen with Logitech web cam
- 12 volt 5,000 mAh battery, two Reedy
- 7.4V lithium packs, one Reedy 11.1V lithium pack, 4-9V
- Five BASIC Stamp 2 and BS2PX microcontrollers
- Propeller servo controller
- Two HB-25 motor controllers
- 24 LEDs
- Apple Mac Mini G4
- Apple wireless keyboard and mouse
- Log Me In remote desk top application
- PC laptop
- DVI-to-RCA adapter
- Belkin audio and video cables
- DC to AC power inverter
- 15 Hitec servos with 133 oz-in torque
- Servo Erector set brackets, bearings, tubing, hubs, and hardware
- Ping))) sensor, dual axis accelerometer, temperature sensor, photoresistor

Most parts are from www.Parallax.com and www.Lynxmotion.com

microcontroller allows independent control of both HB-25 units through a single I/O line.

PBASIC was used to create a program using ASCII code, serial data, IF THEN statements, and the debug terminal to drive both motors simultaneously by pressing designated keys on a keyboard terminal. With the USB-to-serial cord plugged into a computer and connected to the BS2, the user can drive YT4 right from a laptop within cord range.

Accomplishing the goal of remote operation is done by first mounting a Mac Mini with a 1.5 GHz processor on YT4's middle deck. With the Mac Mini in place, the original power cord is used and plugged into a 150 watt DC to AC power inverter mounted on the lowest deck level (see **Figure 7**). The power inverter is spliced into the main 12 volt wire harness providing the necessary power to run the Mac remote system.

With the LCD screen on top, the Mac's active desktop is able to be viewed. For all initialization testing, the Mac with a wireless keyboard and a wireless mouse were used to view everything on the LCD screen. I used Wi-Fi to take full control of the Mini with a PC laptop using the "Log Me In" remote desktop application. With full control of the Mac system, the user can now load the PBASIC code into the Stamp editor and drive YT4 from any given location around the world — all from a laptop.

Complications

Software compatibility became a problem when using

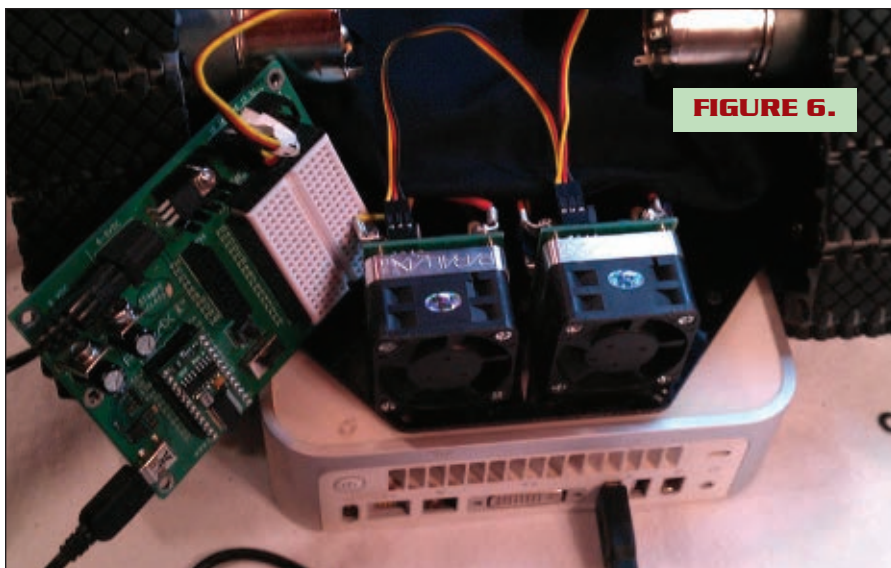


FIGURE 6.

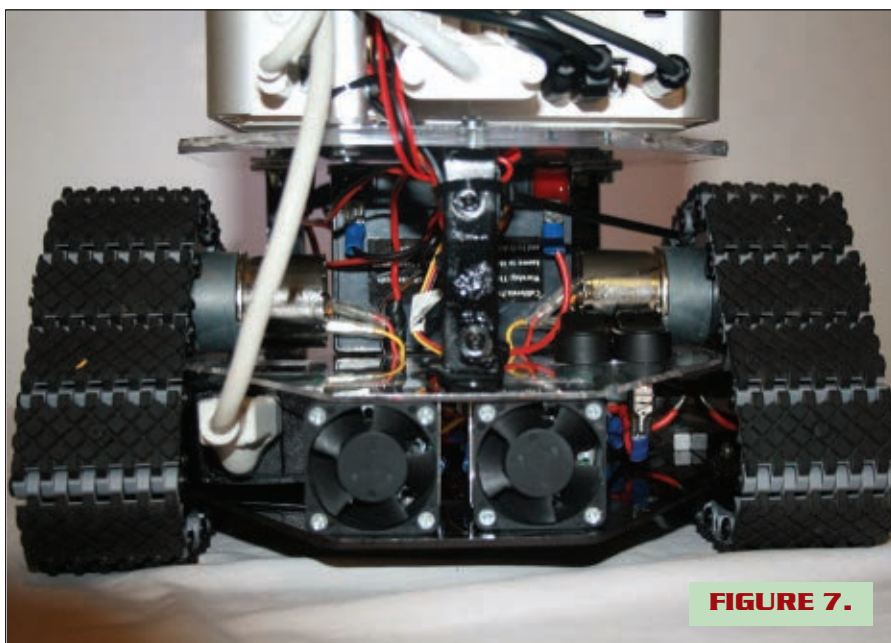


FIGURE 7.

a Mac and PC together. Every great idea was met by some barrier posed by the Mac. The original plan was to use several different software programs for control or operation but not one of them was Mac compatible. Instead, the solution to the problem was to create an original control program.

Another problem that was a factor was the Wi-Fi signal. If signal was lost, all remote control was lost as well. Using a USB network adapter could help, but still could pose a potential problem for the user.

Future Expansion

Future goals include building longer, wider tracks and designing a different frame structure. Once a larger track system is built, using larger motors to operate at higher speeds carrying twice the load will be possible.

The potential for expansion is infinite, creating opportunities beyond immediate imagination. **SV**

Using Advanced Sensors with VEX

“Hear Me, See Me, Feel Me, Touch Me ...”

By Daniel Ramirez

The year was 1969, strobe lights were beaming, and these were some of the haunting lyrics from the song “Pinball Wizard” sung by Roger Daltrey from the original rock opera TOMMY, which was written by lead guitarist Pete Townshend and performed by the legendary British super rock group, The Who. While this song is not particularly about sensors, robotics, or VEX for that matter, its lyrics do in essence summarize what an autonomous anthropomorphic robot is required to do in order to perform its daily tasks. We humans cannot get around on our own without most of these senses available to us. One thing missing from this list is the sense of smell which is very useful for detecting gas leaks, explosives, etc.

In this article, I will describe each of these human senses and the VEX sensors that can be utilized in a similar manner to build equivalent anthropomorphic robotic platforms. To make things more interesting, I’ll include a simple project that demonstrates using a particular sensor, the VEX microcontroller, and some additional electronic components. I will also describe how to interface this controller to other sensors that are not yet part of Innovation First’s inventory. I’ll start with an overview of the current sensors.

What Are Sensors?

Sensors play an ever-increasing important role in the development of almost any new commercial, industrial, transportation, medical, automation, aerospace, or robotic application. Consumer appliances in particular need to be energy efficient to obtain an Energy Star rating from the US government. Washers, dryers, and dishwashers require very efficient electric motors, sensors to measure tilt for balanced loads, and humidity, temperature, and water sensors. The sensors are required to detect if the washer or dryer door has been opened during operation to avoid injury to the operator.

In transportation, sensors play a critical role in measuring speed, altitude, and location (GPS) of an aircraft in flight. Rate gyros and laser ring gyros are used for inertial navigation and radar to detect the presence of other nearby aircraft in order to avoid collisions. Trains depend on various sensors to detect other trains on the track, cars at train crossings, and train speed. Ships use radar and sonar to locate other ships and land, as well as rocks and other obstacles found in the ocean.

Car manufacturers are under increasing pressure to develop and produce higher mileage vehicles and at the same time make them safer. New hybrid cars require constant battery voltage monitoring, as well as measuring current and power to new electric motors and generators. Car speed and steering wheel angles are measured electronically using encoders. Airbags use accelerometers to detect a collision and deploy them in time to save car passenger’s lives. Weather forecasting systems that we depend on for daily activities and

to get warnings of storms or hurricanes or even tornadoes put sensors to use in combination with satellite imagery or weather balloons to detect pressure, temperature, and humidity levels. Although sensors by themselves seem passive when compared to motors, servos, relays, and other kinds of actuators, they play a crucial role in controlling motor speeds, HVAC temperature, humidity, pressure, voltage, current, etc., using closed-loop control, where sensors provide error feedback back to the control loop.

VEX Sensor Subsystem

The VEX sensor subsystem describes the various kinds of sensors, how they are used, and how these sensors are interfaced to the VEX microcontroller, including: bumper switches, limit switches, ultrasonic rangers, and IR ranger sensors, potentiometers, joysticks, optical encoders, and xyz accelerometers. The plug-and-play nature of the VEX sensors makes it very easy to provide your robot applications with sensory feedback necessary for various control tasks. Some of the more common VEX sensors that are available are shown in **Figure 1**.

Notice that they are all color-coded red to match the VEX Inventor’s Guide sensor subsystem. You may recall the VEX limit switches and optical encoders used previously (*SERVO* April ’11 issue on VEX stepper motor experiments), but we will study these sensors more closely here. These sensors are supported by three C compilers and include: the VEX bumper switch, limit switch, optical encoder, quadrature optical encoder, IR ranger, ultrasonic ranger, potentiometer, xyz accelerometer, and a line following sensor. New sensors are continuously being added by IFI Robotics as they are developed for various contests, and support for them is included in their C tools. Note that the VEX quadrature optical encoder has two cables and the standard optical encoder only has one cable. Although the list of available sensors is growing every year, the five major sensor categories are very similar to our biological senses, and each measure physical properties. Let’s go over the descriptions of the VEX sensors that are

FIGURE 1. Here are some of the sensors currently offered by IFI. From left to right, these sensors include: the VEX bumper switch, limit switch, ultrasonic ranger, and optical encoder. Missing from this figure are the VEX IR ranger, quadrature optical encoder, potentiometer, xyz accelerometer, and a line following sensor. Notice that they are all color-coded red to match the Inventor's Guide sensor subsystem.



currently available, as well as other sensors that play an important part in robotics.

Hearing

The human ear is an incredibly sensitive instrument capable of hearing a broad range of sounds, and at a frequency between 20 Hz and 20 kHz. Bats, on the other hand, can hear up to 100 kHz and use this ability to fly in total darkness using sonar.

Using transducers and microphones, a robot can pick up sounds that exceed a bat's ultrasonic hearing range but unfortunately cannot understand what is being said, unless voice recognition software (such as Dragon Systems) is used or the robot has hardware that allows it to recognize words and phrases, so it can carry out a set of commands.

One of the VEX sensors used to "hear" is the VEX ultrasonic ranger which simulates a bat's sonar by emitting short 40 kHz chirps and receives the echoes in order to compute the distance to objects anywhere from three centimeters to three meters. One setup that can be used for hearing is to connect a microphone (MIC) to one of the VEX microcontroller's analog-to-digital ports (ADC) with a preamp and amplifier. Sounds and vocal commands can be processed by a microcontroller or digital signal processor (DSP). Using a microphone connected to the amplifier increases the signals so that the 10-bit ADC can digitize the sounds into digital values that range between 0 and 1023. Digital filtering may be employed to convert the sounds and to compress the data. Voice recognition involves analyzing the data using algorithms to determine English words or commands. These commands can be used to control your robot or prop using simple vocal instructions such as "START," "STOP," "LEFT," "RIGHT," etc.

Sight

Sensors that let a robot "see" include the light sensor and the IR Ranger sensor. The light sensor can detect if it is light or dark in a room or outdoors. The Ranger uses IR ranging techniques to determine the distance between the sensor and an object nearby. The VEX wireless video camera provides the human operator visual feedback, but does not directly help a robot to see unless the information can be digitized using a video digitizer. Image processing, image recognition, feature extraction, edge detection, filters, FFT, etc., are the ways video information can be used for various robotic applications. Security systems automatically detect and track intruders. Pick-and-place robots are used in manufacturing to recognize the shapes of parts, visually inspect circuit boards, and determine the quality of components.

Feel

Our nervous system (and nerves) are located all over our body, allowing us to feel ambient temperatures and humidity. We feel pain if we bump into obstacles or if we accidentally

touch very hot objects. This sense helps us to prevent injuring ourselves. Robots can use pressure transducers and flexible resistors (and even limit switches) to feel the surface of walls and other objects, or cat whiskers made from piano wire mounted on a sensitive limit switch can be utilized. Vibration sensors, piezoelectric sensors, and accelerometers can detect glass breakage, or can sense if someone is trying to break into a vehicle. Seismographs can "feel" earthquakes and measure their strength on the Richter scale.

Touch

Our tactile senses allow us to feel force or the texture of different surfaces. These tactile senses provide the human interfaces to control robots, including pushbutton switches we touch to turn motors on/off, or to be able to run various applications through a user interface made from touch screens or keypads. Force feedback joysticks can simulate our sense of touch to some degree.

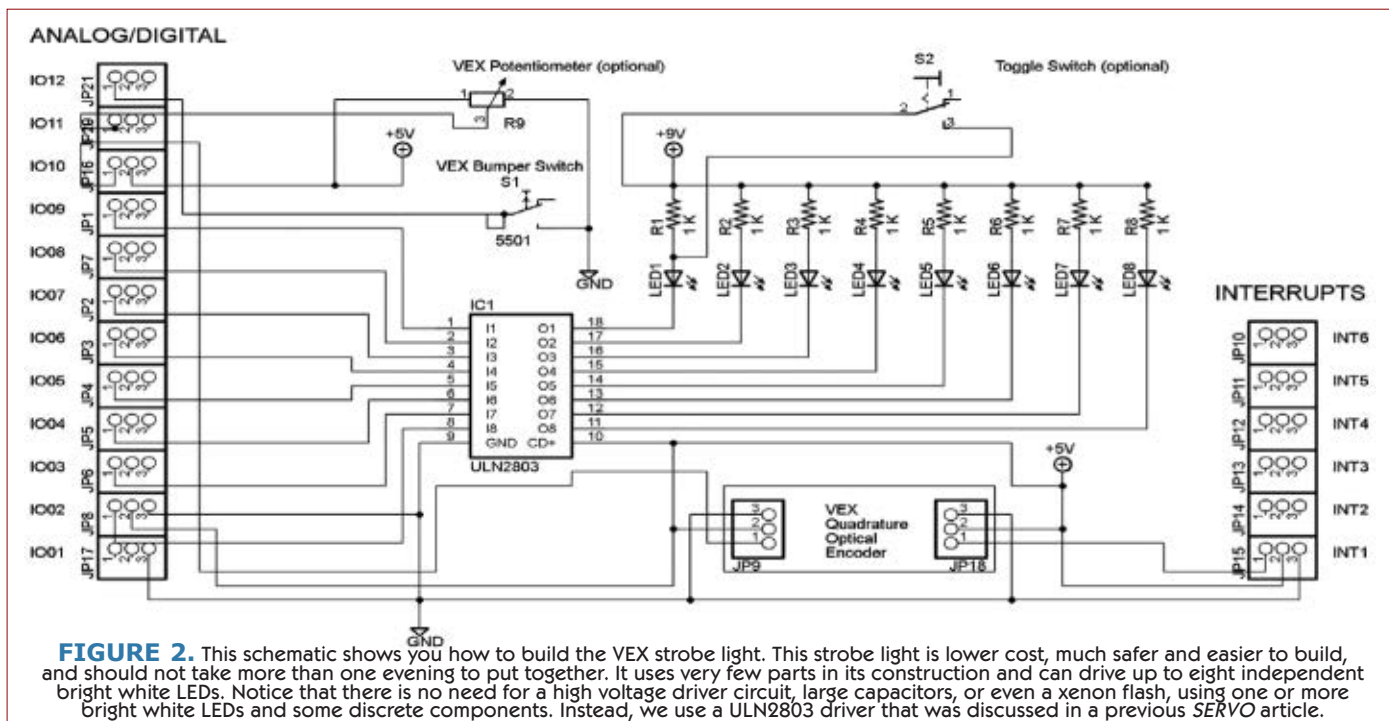
Smell

The other major human sense is smell which is very useful for detecting gas leaks, fire, burning electrical wires, or other such dangers. Sensors are available for detecting carbon monoxide, smoke, and propane or natural gas.

Sensor Experiment #1 — Build The VEX Strobe Light

The scientific use of the strobe light for high speed photography was pioneered by MIT professor Harold "Doc" Edgerton (1903-1990) in the 1930s. Using a flash, he was able to freeze motion and take a picture of a speeding bullet fired from a revolver (www.wikipedia.com). In fact, the Museum of Science in Boston, MA has an excellent exhibit showing some of his experiments. One of these experiments involved water drops from a faucet being frozen in mid air, and another display showing a magic trick with water flowing up, seemingly defying gravity. These are some of the magical things you can do with your VEX strobe light, along with carrying out practical stroboscopic measurements to determine motor speeds (RPM).

What does a strobe light have to do with sensors? Well, the strobe light controls usually include a toggle or pushbutton power switch (sense of touch). They also include one or more potentiometers with dials attached, and a scale to read the flash rate. That's correct — using this dial, the operator can freeze the motion of dancers at a party or determine the speed of a car engine or electric motor, or even how fast a fan is running. (You can even "freeze" water flowing from a



faucet.) The strobe light flash rate (frequency) can be varied using many kinds of sensors including potentiometers, quadrature optical encoders, and rotary encoders. For the purposes of this experiment, we will use the VEX quadrature optical encoder, although the potentiometer would work just as well. A standard optical encoder is not recommended since it cannot detect the direction that the control knob is turned by the operator. The flash rate can be easily controlled using the PIC18 C or Easy C Wait() statement (available from www.vexrobotics.com/products/programming/

mplab.html, www.vexrobotics.com/products/programming/easyc-pro.html, and www.vexforum.com/wiki/index.php/Software_Downloads).

Building The Strobe Light

The schematic shown in **Figure 2** shows you how to build the strobe light. This version is low cost, much safer and easier to build, and should not take more than one evening. It uses very few parts in its construction and can drive up to eight independent bright white LEDs. Notice that there is no need for a high voltage driver circuit, large capacitors, or even a xenon flash. Instead, we use the ULN2803 driver that was discussed in the stepper motor article in the Oct '10 issue of *SERVO*, a pushbutton switch, a VEX quadrature optical encoder, one or more bright white LEDs, and some discrete components. The complete bill of materials for this experiment is shown in **Table 1**. The single bright white LED shown in **Figure 3** should be mounted so that it is kept away from any flammable materials since it can get very hot. The completed VEX strobe light using only a single bright white LED flashing brilliantly is shown in **Figure 4**. It can easily be expanded to handle up to eight flashing LEDs with enough light to brighten any party, however. Using a recycled flashlight or lantern reflector to reflect the strobe light, mount the bright white LED in the place where the original bulb used to be. The diameter of the reflector should be between 2" to 6" to insure that the maximum flash is reflected around a room. The flashlight may be returned to its original working condition after you are done with this experiment.

CAUTION: Don't stare directly at the bright white LEDs or touch them since they can get hot while operating. Also be aware that flashing lights have been known to cause epileptic seizures in individuals who are susceptible to them. If you know of anyone with this condition nearby, then do not operate the strobe light. If you start feeling dizzy or disoriented, then turn the strobe light off and do not use it.

TABLE 1. Bill of Materials required to construct a VEX strobe light with up to eight bright white LEDs.

ITEM	QTY	DESCRIPTION	SOURCE
1	1	VEX microcontroller	Innovation First, Inc. www.vexforum.com
2	1	VEX 9.6 volt battery	Innovation First, Inc. www.vexforum.com
3	2	ULN2803 inverted octal driver	SparkFun www.sparkfun.com
4	1	Wire-wrap cable	RadioShack www.radioshack.com
5	1	*Package of jumper cables	SparkFun www.sparkfun.com
6	1	Flashlight or lantern	Hardware Store
7	1	VEX quadrature optical encoders	Innovation First, Inc. www.vexforum.com
8	1	*VEX potentiometer	Innovation First, Inc. www.vexforum.com
9	1-8	Bright white LEDs	SparkFun www.sparkfun.com
10	1-8	100 to 470 ohm resistors	RadioShack www.radioshack.com
11	1	VEX pushbutton switch	Innovation First, Inc. www.vexforum.com
12	1-8	*Toggle switches	RadioShack www.radioshack.com
13	1	9 volt alkaline battery	RadioShack www.radioshack.com
14	1	Circular protractor (0-360 degrees)	Office Supply Store

*Items are optional.

Also make sure that you keep a safe distance from any moving object that you are trying to “freeze” using the strobe light. The idea is to have fun and not to get hurt.

The VEX pushbutton switch connected to IO12 is a good example of a digital sensor that simulates our sense of touch, and which has two states: ON = 0 or OFF = 1. It is used in this experiment to turn the strobe light on or off when toggled. The example provided with this article not only controls the flash rate, but also doubles as a motor speed control or servo position dial using **Listing 1** as a starting point. Now that the strobe light hardware is completed (including the strobe light frequency setting dial as shown in **Figure 5**), we can download the Easy C Professional firmware necessary to control the strobe light using sensors. The sensors include a potentiometer or a quadrature encoder which is used to vary the strobe light flash rate (frequency). The VEX quadrature optical encoder that is connected to interrupt 1 on the Interrupts block and IO10 on the Digital Analog block provides the frequency control in flashes per second. It is convenient to attach a small VEX gear to the encoder shaft and use it to dial a particular strobe light frequency. By making a small change to the firmware, you can use the potentiometer connected to IO11 instead of the optical encoder to control the strobe light.

Operating The Strobe Light

Operating the strobe light requires an alkaline nine volt battery for maximum brightness. The VEX bumper switch toggles the strobe light on or off. The optional toggle switch is used to change to high power “party” mode by shorting the resistor and allowing extra current to flow into the LED. Make sure the LED is flashing and not on continuously, and use this mode with caution since it can shorten the life of the LED.

Use the potentiometer or quadrature encoder to increase the flash rate by turning it clockwise (CW) or

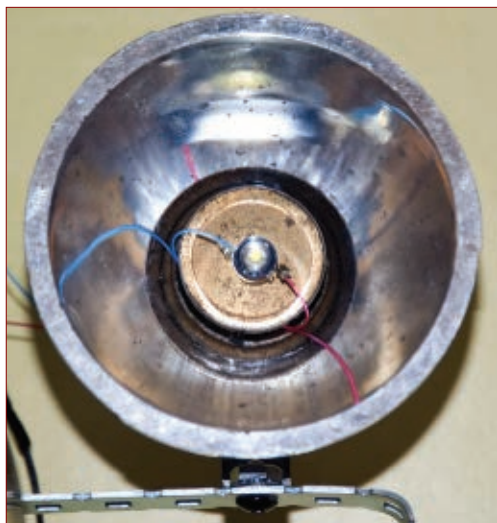


FIGURE 3. The single bright white LED shown in this figure should be mounted so that it is kept away from any flammable materials since it can get very hot.

FIGURE 5. Shows the completed VEX strobe light hardware that will be used to carry out stroboscopic experiments including the strobe light frequency dial attached to the VEX quadrature encoder.

decrease the flash rate by turning it counter-clockwise (CCW). Note that the original VEX encoders did not provide the output necessary to determine the direction. Only the newer quadrature optical encoders have this capability.

Strobe Light Calibration

How can we find out if we are measuring the correct RPM? When using sensors, they usually need some kind of calibration to insure that the results read from the sensor are correct. Unless a smart sensor that has already been factory calibrated is used, it may be necessary for us to calibrate the sensor (in this case, the potentiometer or quadrature optical encoder) using the procedure outlined next. Recall from your high school or college Physics that the frequency of a periodic wave is equal to the reciprocal of its period:

$$\text{Frequency} = 1.0 / \text{Period}$$

We use this equation to control the flash rate using the quadrature optical encoder. An oscilloscope can be used to accurately calibrate the strobe light by simply connecting one of the scope's probes to the digital I/O pin (which is also connected to the LED) and measuring the signal's period for a given potentiometer or quadrature optical encoder angle. The angles are read from a circular protractor that is used as a scale for the strobe light. The critical angles include the minimum angle, the maximum angle, and an angle midway. The remaining angles can easily be interpolated. By using a specific time delay for the period in Easy C with the Wait() statement, we make the strobe light flash a specific number of times per second or per minute. Using this fact, we can convert the angles to flashes per second (FPS) or to revolutions

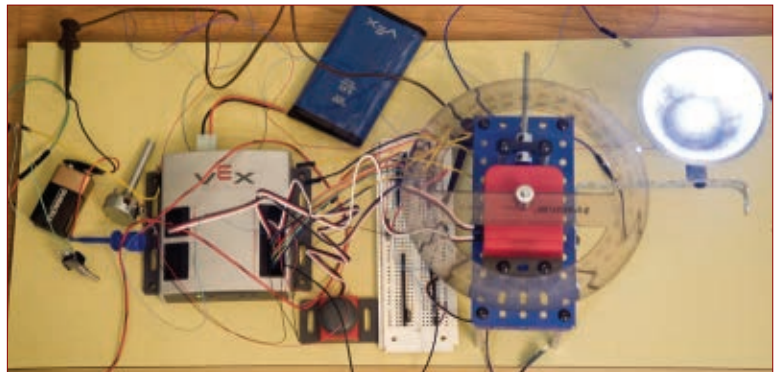
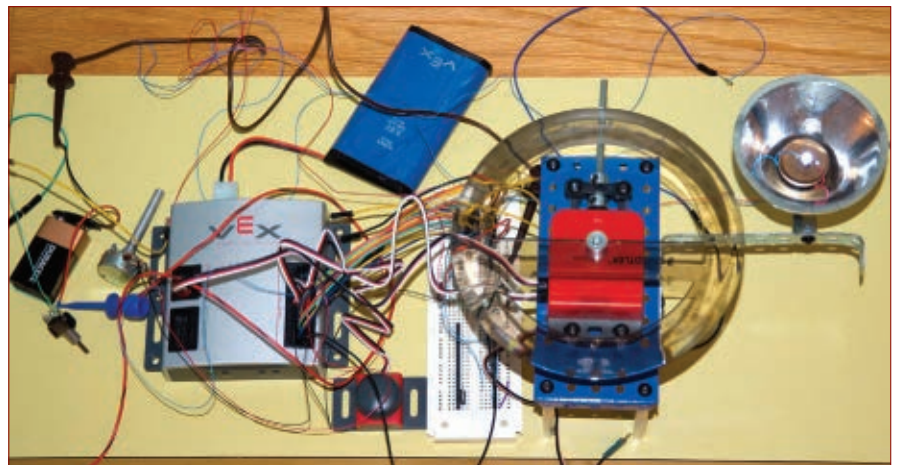


FIGURE 4. The completed VEX strobe light using only a single bright white LED flashing brilliantly, although it can easily be expanded to handle up to eight flashing LEDs with enough light to brighten any party.




```

#include "Main.h"
void main ( void )
{
    long Rot = 0; // # of rotations
    long Delay = 0; // Delay between pulses
    long Period = 0; // Strobe Period (milliseconds)
    long Cycle = 0; // Number of cycles
    float RPM = 0; // Number of Revolutions Per Minute
                    // (RPM)
    float Period_In_Seconds = 0;
    float Frequency = 0.0; // Strobe Light Frequency
    int Power_Switch = 1; // Bumper Switch Input
    int Toggle = 1; // Toggle On/Off
    // Control up to eight strobe lights
    // Start and Preset encoder
    StartQuadEncoder ( 1 , 10 , 0 ) ;
    // Start the Quadrature Optical Encoder
    PresetQuadEncoder ( 1 , 10 , 0 ) ;
    // Preset Quadrature Optical Encoder to 0

    while ( 1 )
    {
        Power_Switch = GetDigitalInput ( 12 ) ;
        // Toggle On/Off using VEX bumper switch or
        // pushbutton switch
        if ( Power_Switch == 0 ) // Toggle the switch state
        {
            Toggle *= -1 ; // Change the toggle state
            Wait ( 25 ) ; // Debounce the button
        }

        //Period = GetAnalogInput ( 11 ) ;
        // Read the VEX Potentiometer
        Period = GetQuadEncoder ( 1 , 10 ) ;
        // Get the latest Quadrature Optical Encoder counts
        // to set the Strobe Light Period
        //PrintToScreen ( "Period = %d\n" , (int)Period ) ;
        // Display value read from quadrature encoder
        if ( Period > 0 ) // Check if Period is negative

        if ( (Cycle++ % 25) == 0 ) // Display Period every
        25 cycles to improve realtime performance
        {
            Period_In_Seconds =(float) Period / 1000.0 ;
            // Compute Period in units of seconds
            Frequency = 1.0 / Period_In_Seconds ;
            // Compute Strobe Light Frequency
            RPM = Frequency * 60.0 ; // Compute RPM from
            current strobe light Frequency
            PrintToScreen ( "RPM = %d\n" , (int)RPM ) ;
            // Display current RPM measured by strobe light
        }
        if ( Toggle >= 0 ) // Strobe Light is On
        {
            SetDigitalOutput ( 2 , 1 ) ; // Turn Flash #1 ON
            SetDigitalOutput ( 3 , 1 ) ; // Turn Flash #2 ON
            SetDigitalOutput ( 4 , 1 ) ; // Turn Flash #3 ON
            SetDigitalOutput ( 5 , 1 ) ; // Turn Flash #4 ON
            SetDigitalOutput ( 6 , 1 ) ; // Turn Flash #5 ON
            SetDigitalOutput ( 7 , 1 ) ; // Turn Flash #6 ON
            SetDigitalOutput ( 8 , 1 ) ; // Turn Flash #7 ON
            SetDigitalOutput ( 9 , 1 ) ; // Turn Flash #8 ON
            Wait ( Period/2 ) ;
            SetDigitalOutput ( 2 , 0 ) ; // Turn Flash #1 OFF
            SetDigitalOutput ( 3 , 0 ) ; // Turn Flash #2 OFF
            SetDigitalOutput ( 4 , 0 ) ; // Turn Flash #3 OFF
            SetDigitalOutput ( 5 , 0 ) ; // Turn Flash #4 OFF
            SetDigitalOutput ( 6 , 0 ) ; // Turn Flash #5 OFF
            SetDigitalOutput ( 7 , 0 ) ; // Turn Flash #6 OFF
            SetDigitalOutput ( 8 , 0 ) ; // Turn Flash #7 OFF
            SetDigitalOutput ( 9 , 0 ) ; // Turn Flash #8 OFF
            Wait ( Period/2 ) ;
        }
    }
}

```

LISTING 1. This listing shows you how to read sensors including the VEX bumper switch, quadrature optical encoder, and a potentiometer used to control the strobe light.

per minute (RPM). Another method is to use a device with a known rotational rate. For example, we can place a target on a standard turntable that has speed settings of 33, 45, and 78 RPM and freeze it using the strobe light. Use these speeds to calibrate the low speed settings of the strobe light and then convert the number of FPS to RPM; use this for making a scale for the dial. Once it has been calibrated, we may need to periodically check that it does not get out of calibration by repeating the same process on known test points — especially if we use the VEX potentiometer which can be temperature sensitive. The strobe light calibration results can also be compared to those using a second quadrature optical encoder to obtain the desired motor speed by attaching it to the output axel and measuring the RPM directly.

Stroboscopy

Stroboscopy is a technique used to indirectly measure the speed of motors and other moving objects using a strobe light. Using the calibrated strobe light, we can measure motor speed by mounting a gear onto its axel and placing a small strip of tape near the edge that acts as a target. Place the strobe light close to the motor and gear, and turn it on by pressing the pushbutton toggle switch. Then, slowly turn the optical encoder or potentiometer control clockwise or counter-clockwise until the target on the gear is frozen. Proceed to read the RPM from the calibrated dial. For a more detailed explanation of stroboscopy, see the article on Wikipedia (www.wikipedia.com).

Firmware

There are Easy C, Easy Professional, and PIC18 C functions that enable the VEX user to read digital and analog inputs which are common to all three C compilers. For this

experiment, we used Easy C Professional since the examples written in this language can easily be ported to ROBOT C and PIC18 C. It is a good idea for the reader to get familiar with the C programming statements relating to digital and analog inputs since we will be relying on them for future experiments. You will find many ways to accomplish programming tasks in C, depending on which C compiler you use and what libraries you include that will get you positive results.

The Easy C professional application strobe light experiment shown in **Listing 1** demonstrates how to read sensors including the VEX bumper switch, quadrature optical encoder, and a potentiometer used to control the strobe light. We can also substitute a VEX potentiometer in place of the encoder. In order to do so, just comment out the quadrature encoder statement and include the potentiometer statement by removing the comments in front of it. The complete source code for this article is available on the *SERVO* website at the article link provided here.

Wrapping It Up

What have we learned from this sensor experiment? First, we described all the sensors that are available from IFI that correspond to our own biological sensors, and how they are used in commercial products and on the VEX system. We then learned how sensors are supported with the three C compilers with some Easy C Professional code examples and showed how the VEX sensors are reliable, robust, and very easy to use in projects since they are literally plug and play. In addition, we provided a simple experiment that demonstrated how to use a quadrature optical encoder, a potentiometer, and a pushbutton in order to control the strobe light. Next time, we will cover more VEX sensors and include another sensor experiment which should also be a lot of fun. **SV**

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ROBOTICS

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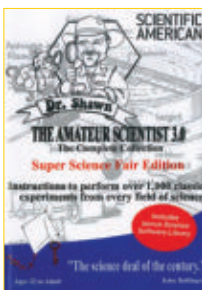
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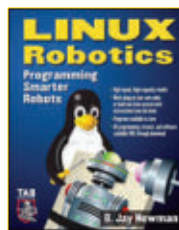


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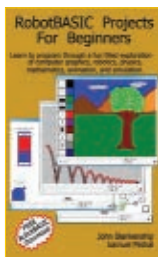
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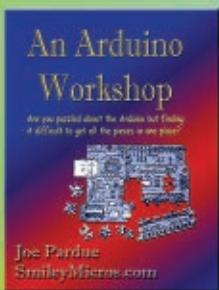
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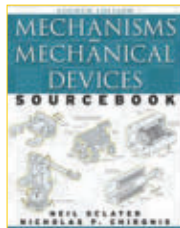
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Forbidden LEGO

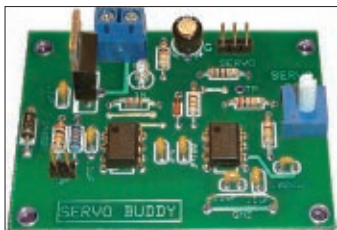
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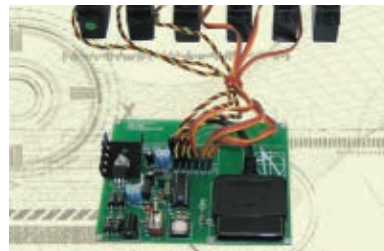
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The NXT Big Thing #13

Wii Wii!

By Greg Intermaggio



Aloha muchachos! Welcome to the second half of our foray into controlling Eddie 2.0 by GyRoScOpE! If you haven't already, be sure to pick up last month's edition of *SERVO* to catch up. Last month, we spent some time experimenting with HiTechnics gyro sensor, and ended with a program that can output the absolute angle of the gyro sensor rather than outputting the raw sensor readings in degrees per second.

This time, we're going to be building on what we already have in order to get our controller talking to Eddie so he can move forward, backward, left, and right based on our hand movements.

Let's rock.

Next Steps

Let's get started by opening up our Gyro_Test_3 program from last month. Once opened, save it as Gyro_Test_4 so we can start fresh.

Once you've completed the instructions, go ahead and give your program a test and see if your second sensor is working.

Gyro Test Program 4 Instructions

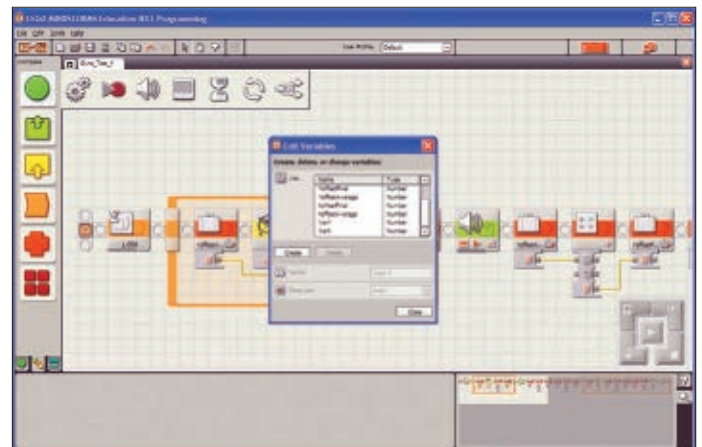


Figure 1. Start by creating the variables shown above. You should already have all of the Y variables from last time. Now we need to create the same three variables for our X axis.

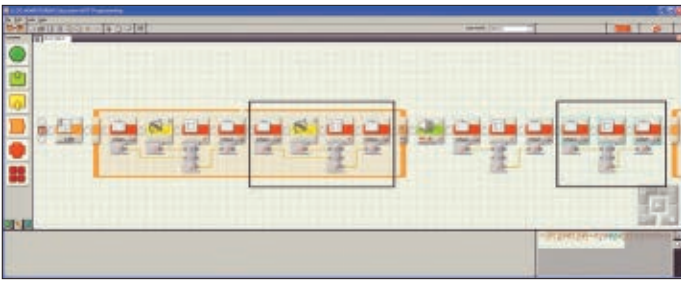


Figure 2. Next, we're going to recreate the portions of our program dedicated to calibrating the Y axis, and switch the variables to our X variables and sensor port to four for our second gyro sensor.

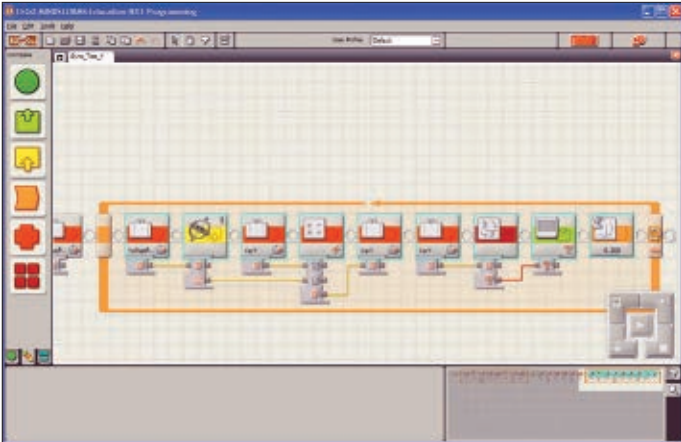


Figure 3. Select all of the blocks inside of the final loop in the program. Hold Ctrl, and click and drag the blocks up and out of the loop, creating a duplicate of those blocks that will be saved for later.

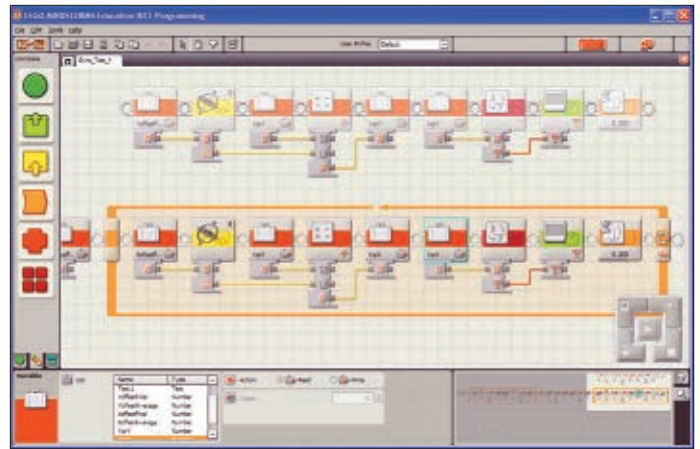


Figure 4. Finally, switch all of the Y variables in the loop to their X variable components, and switch the reference to the gyro sensor on port 3 to port 4.

Making the Controller

Now that we've got the majority of our programming done for Eddie's gyro controller, let's put together the physical controller in a way that we can use it.

Go ahead and test your program again after completing the instructions. When you hold the NXT and swing it left and right, you should see the number displayed on the LCD increase and decrease.

Gyro Controller Build Instructions



Sending the Numbers

Now that we've programmed both of our gyro sensors for Eddie's controller, we need to send that data to Eddie so he can interpret it and change the numbers into movement. Start by saving Gyro_Test_4 as Gyro_Control_Test so you have a backup. Then, follow these instructions:

Gyro Control Test Instructions



Figure 1. Start by selecting the currently unused portion of code above your main loop. We're going to be dragging it in to the main loop such that the Y variable section comes before the X variable section, and the .2 second delay comes at the end.

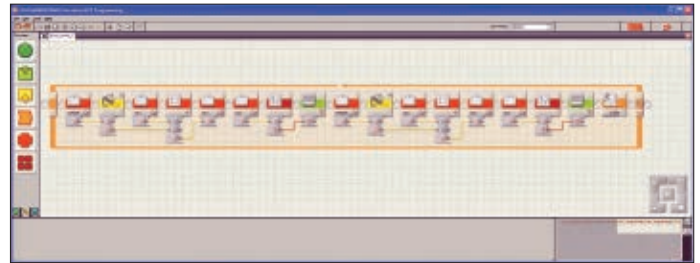


Figure 2. Your program should now look like this.

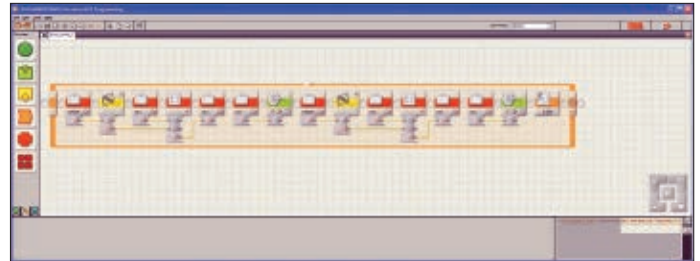


Figure 3. Remove the Number To Text and Display Blocks, and instead, add Send Message blocks. The VarY value should be sent to mailbox 1, and the VarX value should be sent to mailbox 2. Be sure to select "Connection" number 1 for each of the blocks, and "Number" for the type of variable.

Receiving the Numbers

We can't just send our sensor values off into space and

hope someone hears them! We're going to need to write a program for Eddie to receive them. Follow the steps below to find out how.

Gyro Receiver Test Instructions

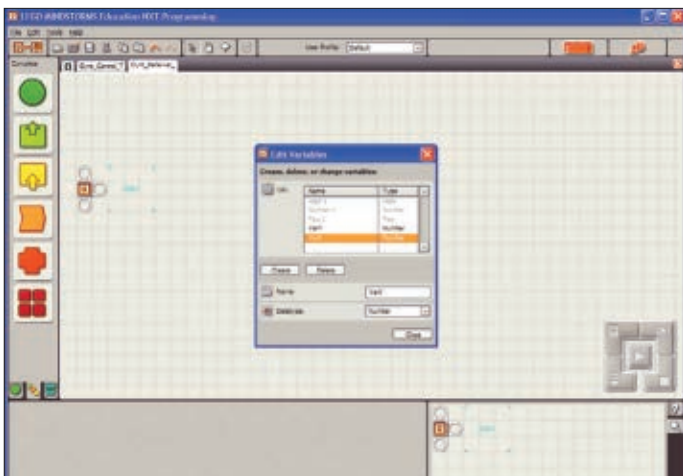


Figure 1. Create a new program called Gyro_Receiver_Test and define number variables VarY and VarX.

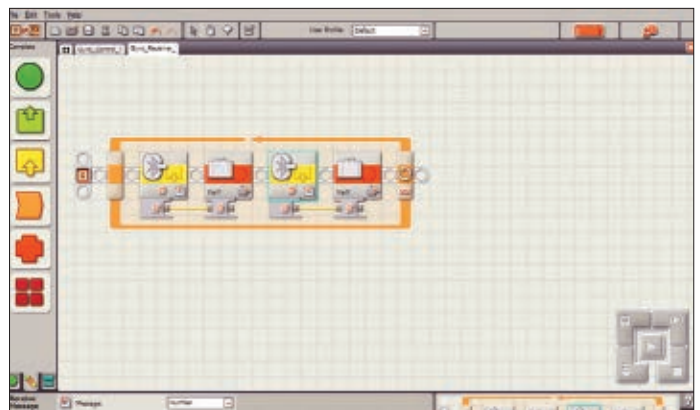


Figure 2. Create a loop. Inside the loop, add two Receive Message blocks and two Variable blocks set to write, arranged as indicated. Set the mailbox to the first Receive Message block to 1 and the Message type to Number. Run a data wire from the Number out data hub on that first block to the input of the first Variable block which should be set to VarY. Repeat the process for the second Receive Message block. It should be set to mailbox 2, and written to VarX.

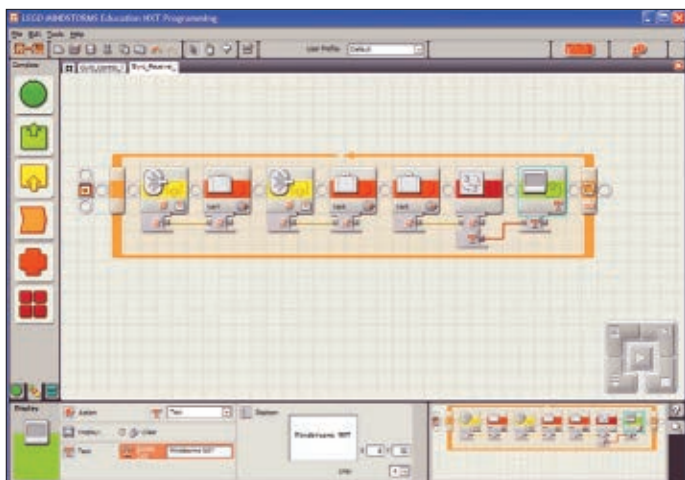


Figure 3. Add a Variable block set to Read, a Number To Text block, and a Display block, all wired up as indicated to display the VarX variable.

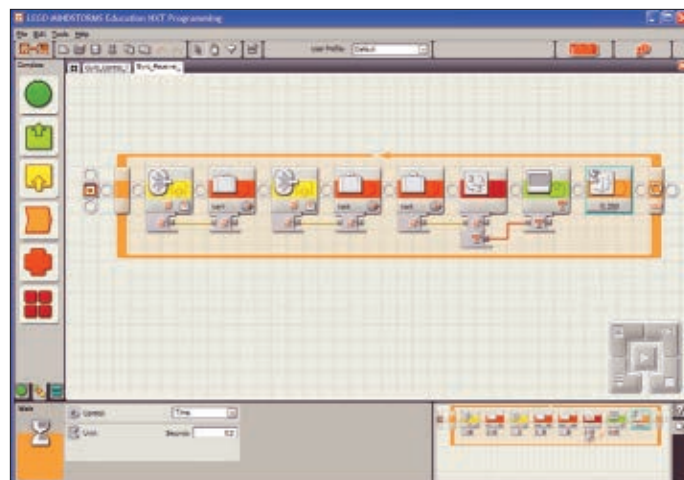


Figure 4. Finally, add a .2 second wait at the end.

Putting It All Together

Download the control program to your controller and the receiver program to Eddie. Then, connect the NXTs via Bluetooth and run both programs. Remember not to move the control while it's calibrating!

If all goes well, swinging the controller left and right should decrease and increase the number displayed on Eddie's screen. You may also want to have Eddie display VarY to make sure that it's working properly, too.

The Final Touch

Alrighty, roboteers. So far, we've learned about gyro sensors, hacked them to give us a value we can use, created a handheld Bluetooth controller using our hacked sensors, written a program to send out sensor values to Eddie, written a program to receive the sensor values on Eddie, and we aren't even finished yet!

The last thing we need to do is make Eddie react to his sensor values. It's actually pretty simple.

Gyro Receiver Final Instructions

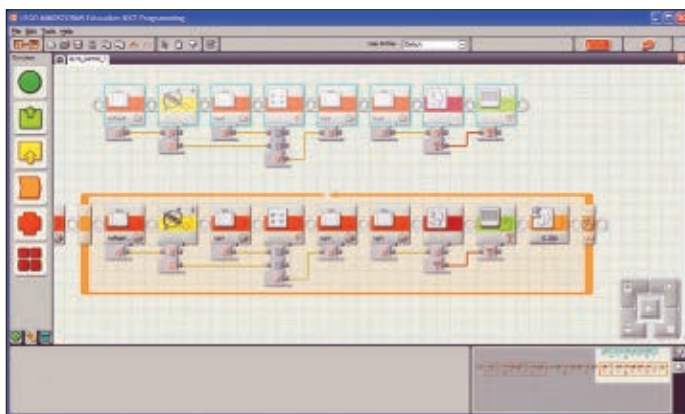


Figure 1. Save your Gyro_Receiver_Test program as Gyro_Receiver_Final. Then, delete the Number To Text and Display blocks.



Figure 2. Add two variable blocks. Set the first to read VarY and the second to read VarX. Add a move block, and run VarY to the Power data hub and VarX to the Steering data hub. Finally, set the motor duration to Unlimited.

There are a lot of ways our complex programs can go wrong, so download the receiver program to Eddie and the controller program to your control. Test them and proceed to the troubleshooting section below if you have issues.

Troubleshooting

Because we only did a very basic gyro control program, there are many things it does that might not work the way you want them to. The beauty of NXT is that you can customize your program to be perfect for your own needs. This troubleshooting section doubles as an "ideas for improvement" section. At some point, we'll revisit the idea of gyro control and implement some of these ideas. Until then, feel free to experiment on your own.

Eddie doesn't move at all.

- Make sure to connect the controller to Eddie via Bluetooth. You can tell they're connected when there's a small diamond overlapping the Bluetooth symbol on each of their displays.

Eddie turns the wrong direction.

- Simply swap his motor ports. Plug B into C,

and C into B.

Eddie moves sporadically/I have trouble controlling him.

This could be one of several issues:

- Be sure to have your controller completely stationary while it's calibrating.
- When you start your program, your controller has to be at its 0 point. Calibrate your controller in a comfortable position to move it from. ANY movement from its calibration point will correspond to movement in Eddie. You could fix this by programming an NXT button to reset both VarX and VarY. This would effectively create a Reset Origin and Pause button at the same time.
- You may also want to make Eddie less sensitive to your movements. The easiest way to do this is divide VarX and VarY by a small number just before they reach Eddie's motors.

Eddie won't move backwards.

- I didn't program him to, just yet! The best way to do this is to create a switch in your program. If VarY is greater than 0, you want Eddie to move forward. If the reverse is true, he should move backward.

Wrapping Up

What a whammy! We just programmed Eddie to be controlled by gyroscope. How cool is that! Stay tuned for next month's installment of The NXT Big Thing! **SV**

www.servomagazine.com/index.php?/magazine/article/august2011_Intermaggio

Greg "LEGO" Intermaggio lives in the Bay Area, CA, where he runs a business called Techsplosion, bringing hands-on science to all ages and walks of life. In his spare time, Greg

likes to unicycle, juggle, unicycle juggle, and battle killer robots! More information about Greg can be found at **Intermaggio.com**. More information about Techsplosion can be found at **Techsplosion.org**



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Then and NOW

UNIQUE ROBOTS HELPING MANKIND

by Tom Carroll

Robots come in many sizes, shapes, and functional capabilities, and are designed to help mankind in many different ways. It's easy to see how industrial robots simplify operations and make manufacturing a lot safer for workers, but how about the many other applications most of us never get to see or experience? Surgical robot systems are making once-complicated operations a lot easier to perform — a fact that I have come to realize when I was just diagnosed with prostate cancer and will undergo robotic surgery this September. We've seen news clips of the robots that surveyed and assisted in last year's Gulf oil spill repairs and cleanup, and others that crawl into oil pipelines for inspection. Some of the most unique robots in the world (or should I say in our solar system?), are space robots, and the US now has some spacecraft that are leaving our solar system for deep interstellar space, but I'd like to start with a unique robotic solution here on Earth.

Robots Assist Japan with their Nuclear Plant Disaster

Military robots are assisting our armed forces far away in the Middle East, yet some were adapted to help Japan in a most valuable way. I was watching a news program the other night and one of the field reporters was remarking just how valuable robots have become throughout the world. She was discussing how the robots assisting in the safe inspection and clean-up of the Fukushima Daiichi nuclear power plant reactors damaged in the Japanese earthquake were preventing people from getting overdoses of radiation. The US supplied many of the robots used in the massive cleanup of the heavily damaged reactors.

iRobot is known by most people as the supplier of millions of Roomba vacuum cleaner robots for the home. Many others — especially our military personnel in Afghanistan and Iraq — know of the many iRobot military robots being deployed to assist soldiers in the field of battle, especially the mid-sized iRobot PackBots used in multiple ways in the two wars. PackBots are used to defuse IEDs (improvised explosive devices), safely screen people and buildings for explosives, and search high-risk areas such as probable enemy hideouts and even sewers. The PackBot's versatility comes from its capacity to accommodate a wide range of payloads and sensors — including manipulators — all of which are controlled by iRobot's Aware 2 intelligence software that allows for modular, mission-specific

configurations. iRobot has delivered over 3,000 PackBots to the military and other civilian groups around the world.

iRobot has modified this series of military robots into non-military hazardous area devices and they have proven useful in operations beyond the battlefield. Radiation has not been a problem encountered in these wars but the basic platforms have this extreme hazardous duty capability designed into them. These 48 to 60 pound remotely-operated PackBot 510 robot vehicles were just what Japanese officials needed to enter the buildings containing the damaged reactors to determine if the radiation level was safe enough for human entry. It wasn't. **Figure 1** shows a PackBot 510 operating in a high radiation area. The US standard for radiation exposure is a maximum of 50 millisieverts a year;

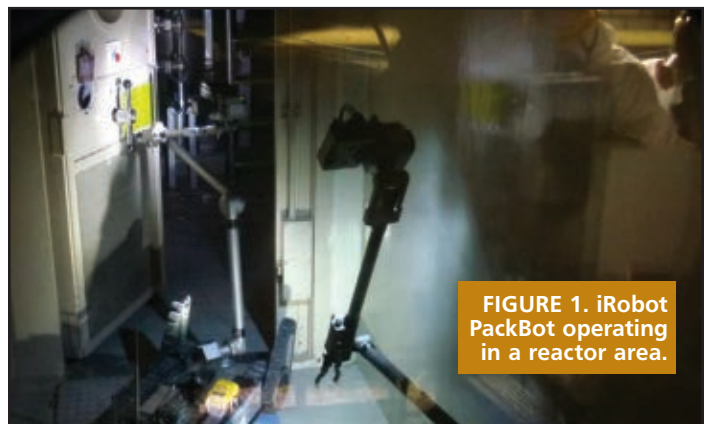


FIGURE 1. iRobot PackBot operating in a reactor area.

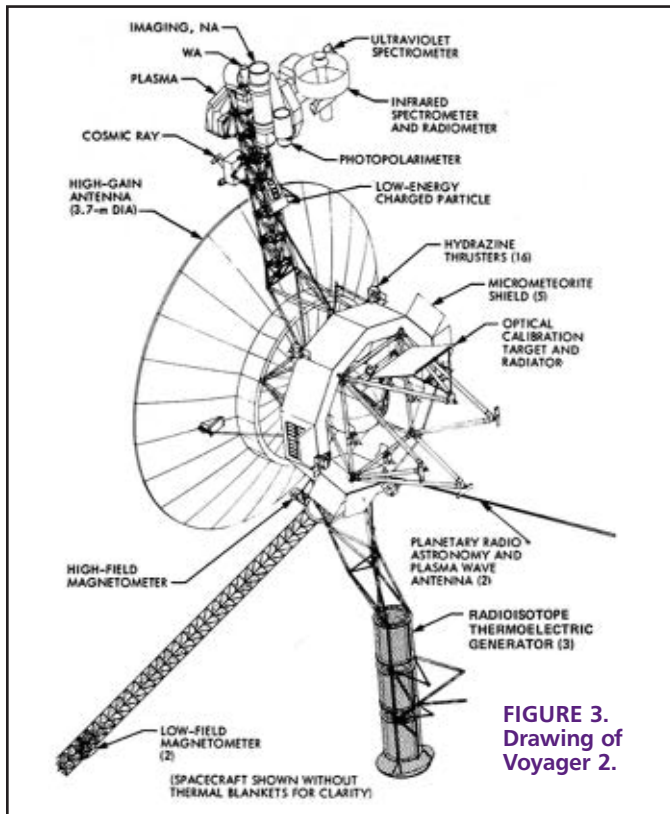


FIGURE 3.
Drawing of
Voyager 2.



FIGURE 2.
Voyager 6 —
V-Ger from the
Star Trek movie.

damages to the plant without exposing pilots to the radioactive sky above. The PackBots were designed to maneuver over battlefield debris to allow military personnel to analyze the physical situation from a safe location. These lightweight robots were nimble enough to do the same in the partially collapsed reactor buildings. Their manipulator arms were fitted with various end-effectors to allow the operators to read and adjust instruments and to examine objects found in the debris. The robots were also fitted with a visible light/IR camera that delivered the images through a fiber optic cable to the controlling operator located in a safe, remote location. These video images allowed repair teams to map out salvage strategies to assist larger heavy-lifting robots, as well as for human clean-up crews.

The heavy-duty robots included two iRobot 710 'Warriors' and the British-designed Talon, created by the British defense firm QinetiQ. It was QinetiQ's American group that sent these robots to Japan. Like the smaller robots, the Warriors and Talons were designed to handle IEDs and other explosives, as well as larger and heavier hazardous materials. The iRobot 710 can handle a 150 pound payload which makes it ideal for carrying its smaller 510 'cousin' into a building and placing it in a location that the smaller robot cannot reach on its own. The 710 was also fitted with a special arm and end-effector to allow it to drag a heavy fire hose to the interior of a building to extinguish a fire or cool an over-heated reactor. As capable as these robots are, they cannot move and manipulate objects as well as a human being, nor can they make on-the-spot observations and therefore impromptu reactions like a human can. Their value comes in their ability to work where no human can (or should) operate.

radiation sickness occurs at 1,000 millisieverts exposure. The Japanese officials doubled their maximum of 125 millisieverts per hour to 250, but quickly found that their workers could only handle five hours, and then not have any additional exposure for a year. This required rotating many hundreds of workers into and out of the buildings, only to be replaced by new workers who had to spend way too much time just to find out what the previous five-hour shift had done. There had to be a better way.

There was. Send in robots to also do physical work. Prior to the first entry of mobile, ground-based robots into the stricken Fukushima Daiichi plant, a US Global Hawk robot drone plane was used to take crucial video images of the plant below. This allowed officials to assess the actual

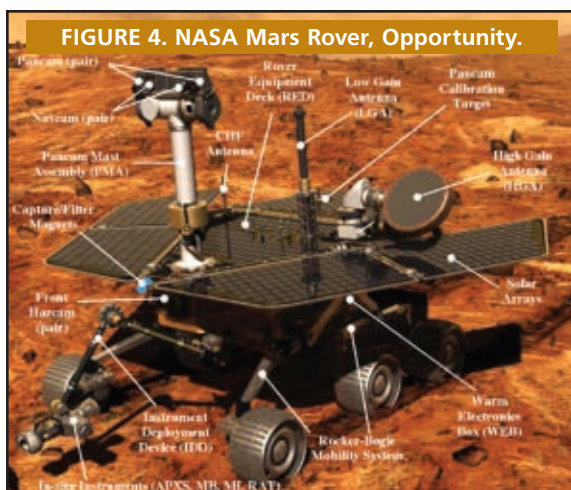


FIGURE 4. NASA Mars Rover, Opportunity.

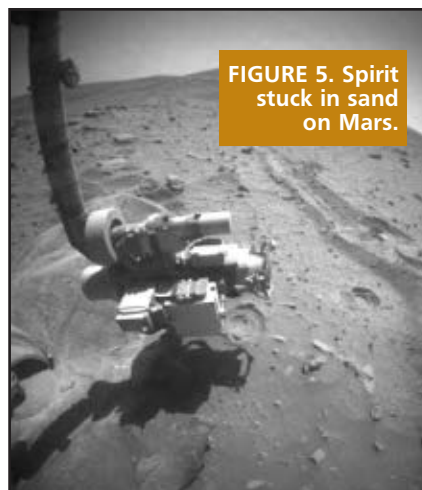


FIGURE 5. Spirit
stuck in sand
on Mars.

Voyager Space Robots Have Lived for Decades

I was privileged to work on several space robot designs for NASA in my years with Rockwell, but many of the most unique and capable spaceborne robotic systems were developed well before or since my departure. There are very few robots that made headlines many years ago, but then some of the same robots are still making headlines decades later.

In 1979, the first Star Trek motion picture depicted a unique villain for Earth that Captain Kirk and his crew aboard the Enterprise had to meet and conquer. V'Ger was the powerful and nasty nemesis that was threatening our planet, though it had — in reality — the intelligence of a mentally challenged slug using 1970's computer technology. It turned out that V'Ger was actually a United States exploratory NASA spacecraft (Voyager 6 shown in **Figure 2**) that was launched centuries earlier. For some reason or another, the middle letters "oya" were burned over during its travel through space, so only V..ger could be read. Well, good old Kirk, Spock, and the others managed to 'defuse' the situation and save Earth.

The twin Voyager spacecraft had been launched only two years before the film's debut, though there was never a sixth spacecraft that was lost as depicted in the film. Voyager 1 — the first of the Voyagers launched — left Earth on August 20th, 1977 and has now traveled over 8.8 billion miles and is past the edge of the solar system's boundary into an area called the heliopause. Voyager 2 — traveling at 335 million miles a year (over 45,000 miles an hour) — soon passed its twin and is now the furthest out. A drawing of the spacecraft is shown in **Figure 3**. Designed to explore the outer gas giants of Jupiter, Saturn, Uranus, and Neptune, Voyager's phenomenal success has allowed it to go beyond our solar system. "The present mission objective of the Voyager Interstellar Mission (VIM) is to extend the NASA exploration of the solar system beyond the neighborhood of the outer planets to the outer limits of the Sun's sphere of influence, and possibly beyond," states NASA.

The amazing thing about these two spacecraft is their ability to last 34 years in deep space where our Sun just looks like a bright star. Their onboard RTG nuclear power supplies offer a constant 470 watts to drive the high power radio transmitters required to send data back to distant Earth. These radioisotope thermoelectric generators convert thermal energy from decaying hot plutonium spheres into electric current since typical near-Sun solar panels would be useless in deep space. The data stream sent back is only 160 bits per second, but enough for Earth-bound scientists to gain quite a bit of information about the deep space environment. There have been a few system failures such as when a telemetered command sent to Voyager 2 in 2006 accidentally turned on an internal heater to the magnetometer and severely damaged it. Weathering this and a few 'flipped bit' errors, these two robot spacecraft have served mankind magnificently for over three decades. Their RTGs will soon stop producing power in the 2020s, and it will be several hundred thousand years before the spacecraft could be considered anywhere close to another star.

Spirit and Opportunity — Visitors to Mars

Another set of long-lived NASA spacecraft have also made headlines, albeit quite a bit closer to Earth — if you can

FIGURE 6. Mars Rover Spirit covered with dust.



FIGURE 7. New NASA Mars Rover, Curiosity.



call Mars 'close.' The NASA Mars Exploration Rover Mission involved two identical rovers launched in 2003 by Delta II vehicles. Spirit left Earth on June 10, 2003 with Opportunity (seen in **Figure 4**) following on July 7, 2003. Both the Spirit and Opportunity Mars rovers were intended to last for just three months, but the hardy Opportunity is still operating after eight years in space and on the surface of Mars. Spirit finally ceased to operate last year.

Spirit had been stuck in a sandpit for over a year and NASA decided that it would best serve as a stationary research platform in January of last year. After a particularly cold Martian winter, NASA finally decided that the Mars-roving robot had met its match, but the hardy little rover provided a lot of valuable data.

Before Spirit's demise, the cold and limited sunlight upon the robot's solar panels had left little energy for two-way communications with Earth. The rover had last sent data to engineers back in March of 2010 and a final attempt was made in May of last year, to no avail. **Figure 5** shows a self-portrait taken by Spirit once it became obvious it was permanently stuck. Opportunity is carrying out a single rover Mars exploration mission from this point on, continuing a 19 kilometer journey on the other side of Mars from Victoria



FIGURE 8. Will Smith runs from a demo robot in the film, *iRobot*.

FIGURE 9. Brokk 330 demo robot.



Crater to Endeavour Crater; 19 kilometers is a major journey for such a small 408 pound rover.

Both of the rovers had endured severe dust storms that covered their solar panels with thick debris, as **Figure 6** shows on Spirit. Normally, the solar arrays on the rovers are able to generate up to 700 watt-hours of power per sol (Martian day) with 150 watt-hours being the minimum requirement before internal battery-powered heaters must be turned on to heat sensitive electronics and instruments. Some storm-deposited dust reduced the output to as low as 89 watt-hours per sol before wind or dust devils removed the dust. You can follow the adventures of these two remarkable robots from way back “then” through the travails of “now” on nasa.gov or Wikipedia. The much larger (size of a Mini Cooper car) RTG ‘nuclear’-powered Mars Curiosity rover that is shown in an artist’s concept in **Figure 7** is scheduled to launch at the end of this year.

Demolition Robots

Since I’ve been referring to science fiction movies, many of you will remember the Will Smith movie, *iRobot*, and his distrust of any robot. In one scene, he was visiting the home of Dr. Alfred Lanning who had just been murdered, supposedly by a robot. Suddenly, without any sort of warning, in the middle of the night, Dr. Lanning’s house started to be demolished by a huge demolition robot, supposedly a typical situation for anyone who dies the day before. This monstrous machine chewed through the house like a hungry kid gulping down a peanut butter sandwich and

our hero barely escaped as shown in **Figure 8**.

Home and building demolition is performed these days in many ways. Large crane-mounted balls or many-ton tracked heavy construction vehicles are still used for total teardown and removal of buildings (such as those heavily damaged in this past spring’s tornado rampages in the mid west). These days for partial restoration and interior upgrades, ‘selective’ dismantling is used in modern construction to quickly remove portions of a building for refurbishment.

Dismantling of concrete slabs, walls, and other interior structural material by manual means is time-consuming and very dangerous. Handheld pneumatic or electric tools are heavy and painful to use for long periods of time.

Two Swedish companies — Brokk and Husqvarna — developed small, track-mounted, remotely-controlled demolition robots several years ago to speed the removal of unneeded construction material quickly and safely. A Brokk 330 demo robot is shown in **Figure 9**. The US company, Stanley, saw the success of these companies and decided to enter this middle weight market. Stanley LaBounty is a business unit of Stanley Hydraulic Tools and recently introduced its latest remote-controlled demolition robot; the F16. Stanley LaBounty is an American company and entered the market through a partnership with Finnish manufacturer, Finmac. It claims that the \$135,000 Stanley F16 demolition robot shown in **Figure 10** is the lightest “with the highest power-to-weight ratio, largest work range, and more proprietary technology and standard features than any equipment in its class.”

The 3,417 pound, track-based, electrically driven carrier base and robot is easily guided through doorways and into enclosed spaces. As Martin Schnurr, president of Stanley Hydraulic Tools, says, “The LaBounty F16 remote controlled demolition robot brings higher standards of power, productivity, and versatility to the mid-size segment, opening new opportunities for contractors to increase productivity and profits. It arrives as more aging or under-used factories, distribution centers, office buildings, apartments, schools, and other properties are viewed as renewable assets worth restoring through interior upgrades rather than total building teardowns.”

The Stanley LaBounty F16 is designed to operate 500 foot-pound impact breakers and 1,500 foot-pound drop hammers, all by remote control from a safe distance. Four self-stabilizing outriggers function separately, automatically raising and lowering to maintain consistent machine balance on uneven surfaces. It has a four-point detachable boom, telescopic arm that reaches to a height of 16.4 feet, and has continuous 360-degree rotation.

One unique application is the clean-out of kilns. It takes days for a large factory kiln to cool down enough for a human to enter, whereas the robot can enter and complete the job much sooner. These robots are ideal candidates for dangerous operations such as inspection and temporary



FIGURE 10. Stanley-F16 demolition robot.

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repairs of the heavily-damaged nuclear reactors in Japan. With a tight economy restraining building budgets, selective demolition by this type of robot can gut the interior for remodel while leaving the shell intact.

The use of concrete crushers instead of hammer breakers allows them to be used within inhabited buildings without disturbing the occupants. These mid-range machines costing from \$135k to \$150k are quite versatile and agile. Brokk's smallest machine can even climb stairs. Many attachments are available for all types of close-quarters operations. Newer models have wireless Bluetooth RF links between the machine and the operator.

Closing Thoughts

In the beginning of industrial robots, there were fewer applications and the robots being designed and manufactured were more specific to a single job or operation. The first designs used different end-effectors (arm/hand) for different tasks. As potential applications grew in numbers and more manufacturers entered the field, robots were being developed that could do almost anything. I thought it was interesting to highlight a few robots that were developed in the 70s but are still in operation today.

Many machines of today can be quickly modified for emergency tasks such as the robots used in the oil spill or the damaged nuclear reactors. Great designs — such as with the two Mars rovers — can create robots that can operate far in excess of their originally designed operating lives. **SV**

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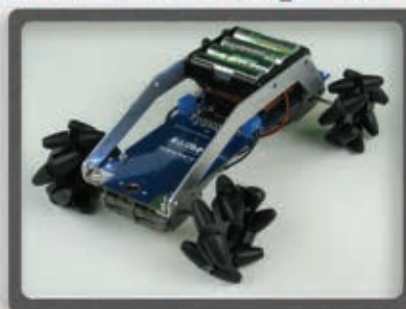
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```
//-----
*
SSD1963_8-BIT
PROGRAM FOR WRITING TO NE-
WHAVEN DISPLAY 5.7" TFT
*/
//-----
DELAY_MS(100);
WRITE_COMMAND(0x01); //SOFTWARE RESET
WRITE_COMMAND(0x01);
WRITE_COMMAND(0x01);
DELAY_MS(10);
COMMAND_WRITE(0x00,0x01); //START PLL
COMMAND_WRITE(0x00,0x03); //LOCK PLL
WRITE_COMMAND(0x80); //SET LCD MODE SET TFT 18BITS
MODE
WRITE_DATA(0x0c); //SET TFT MODE & HSYNC+VSYNC+DEN
MODE
WRITE_DATA(0x80); //SET TFT MODE & HSYNC+VSYNC+DEN
MODE
WRITE_DATA(0x01); //SET HORIZONTAL SIZE=320-1 HIGHT-
BYTE
WRITE_DATA(0x3f); //SET HORIZONTAL SIZE=320-1 LOWBYTE
WRITE_DATA(0x00); //SET VERTICAL SIZE=240-1 HIGHTBYTE
WRITE_DATA(0xef); //SET VERTICAL SIZE=240-1 LOWBYTE
WRITE_DATA(0x00); //SET EVEN/ODD LINE RGB SEQ.=RGB
COMMAND_WRITE(0xf0,0x00); //SET PIXEL DATA I/F
FORMAT=8BIT
COMMAND_WRITE(0x3a,0x60); // SET R G B FORMAT = 6 6 6
WRITE_COMMAND(0xe6); //SET PCLK FREQ=4.94MHZ ; PIXEL
CLOCK FREQUENCY
WRITE_DATA(0x02);
WRITE_DATA(0xff);
WRITE_DATA(0xff);
WRITE_COMMAND(0xb4); //SET HBP,
WRITE_DATA(0x01); //SET HSYNC TOTAL 440
WRITE_DATA(0xb8);
WRITE_DATA(0x00); //SET HBP 68
WRITE_DATA(0x44);
WRITE_DATA(0x0f); //SET VBP 16=13+1
WRITE_DATA(0x00); //SET HSYNC PULSE START POSITION
WRITE_DATA(0x00); //SET HSYNC PULSE SUBPIXEL START POSI-
TION
WRITE_COMMAND(0xb6); //SET VBP,
MORE
```



; USING NEWHAVEN DISPLAY
WITH SSD1963 CONTROLLER

; DO DATE AND TIME

SETIO G, 0xf000 ;SET LOCATION FOR DISPLAY
SETIO U, 0xf800 ;SET LOCATION FOR USB DRIVE
LOAD "FONT.HEX" ;GET FONT TABLE FROM USB
SETGLCD I ;INITIALIZE THE GRAPHICS LCD
SETGLCD C ;CLEAR THE DISPLAY
SETGLCD D1 ;SELECT LARGE FONT

DO

SETGLCD P,(100,200);SET CURSOR POSTION

; DISPLAY TIME

GLCDOUT USING(2),!H," ",!M," ",!S," "

; DISPLAY DATE

GLCDOUT USING 2,!MO,"/",&D,"/",&Y

UNTIL S=1

; ALL DONE



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